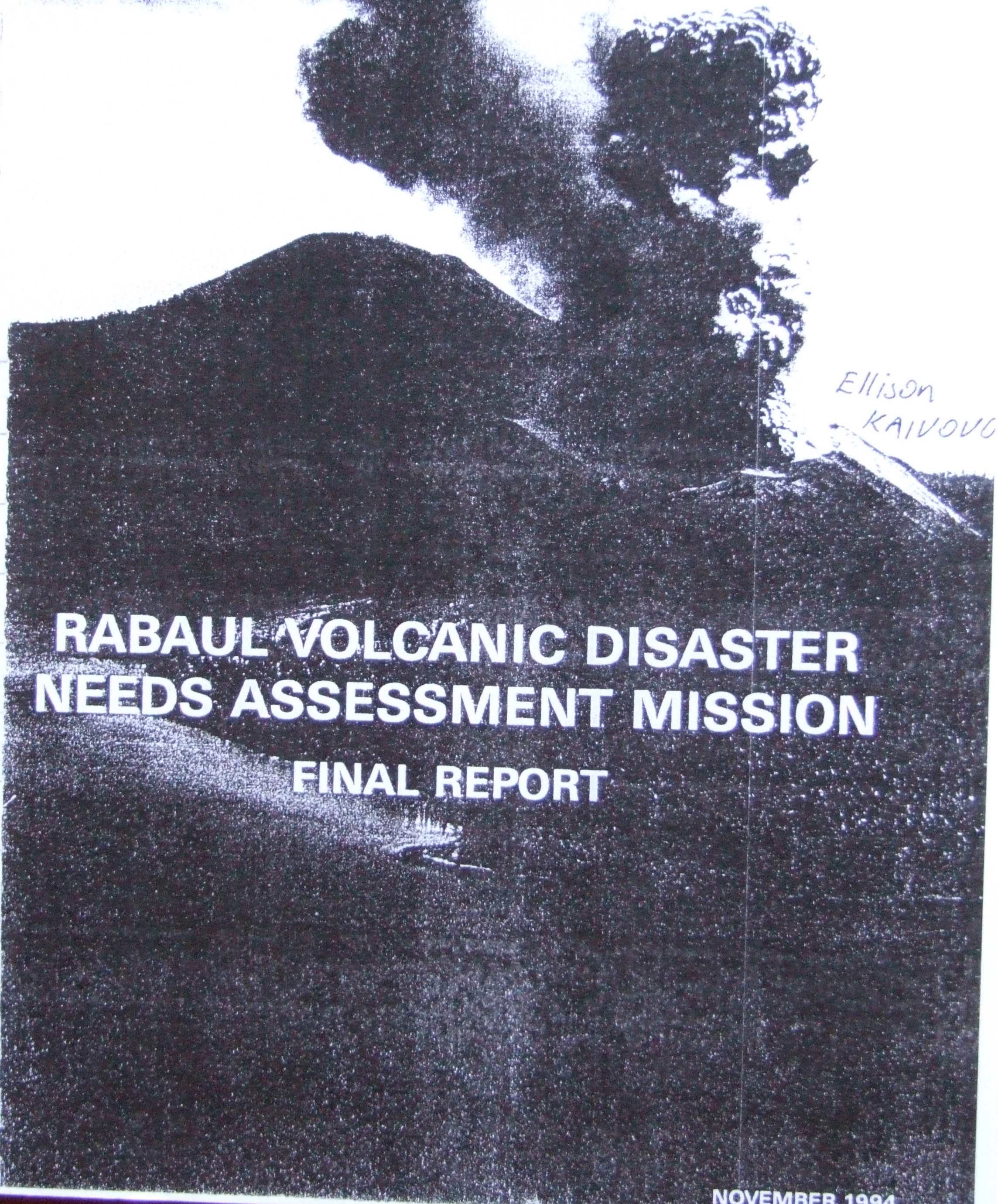
AIDAB

AUSTRALIAN INTERNATIONAL
DEVELOPMENT ASSISTANCE BUREAU



RABAUL VOLCANIC DISASTER NEEDS ASSESSMENT MISSION

FINAL REPORT

NOVEMBER 1994

AUSTRALIAN INTERNATIONAL DEVELOPMENT

ASSISTANCE BUREAU

FINAL REPORT

RABAUL VOLCANIC DISASTER NEEDS ASSESSMENT MISSION

The views expressed in this publication are not necessarily those of AIDAB or the Australian Government

NOVEMBER 1994

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RECOMMENDATIONS

1. An urgent programme of support to upgrade the capacity of the Observatory be provided as a specific exercise in the overall disaster reconstruction program.

   a. This programme includes the procurement and installation of "real time" volcano monitoring equipment and systems.

2. The cost of rebuilding facilities and restoring the functions formerly carried out by Provincial and National departments is of the order of K100 million.

3. Assistance to the education sector in the form of temporary or permanent classrooms, educational materials and teacher housing is urgently needed so that schools can reopen for the new school year.

4. Priority attention should be given to thorough cleaning of all cables, roofing and other metal surfaces to prevent further damage and the health risks associated with ash should be further assessed:

   b. this cleaning programme should be based on a technical assessment of the most effective manner by which all chemical effects of the ash and acid fallout can are halted and that further corrosion is prevented.

5. The building code for structures in volcano prone areas should be amended, steeper roofs becoming mandatory. Technical assistance may be required so appropriate standards can be developed.

6. Light industrial areas in Rabaul should be permitted to reopen for business; however,

   a. Restoration activity in town, including restoration of power, should be kept to a minimum until the end of the wet season.

   b. Work on Kokopo and Burma roads as well as the town roads should be kept to a minimum until the end of the rainy season.

7. The PNG Government should immediately begin implementation of the priority list of projects after a decision has been made on the relocation issue.

8. Rabaul town should be partially redeveloped and remain as the port for the islands region, with accompanying commercial activities.

9. The principle on which future planning should be based is that risk should be reduced to the maximum extent possible consistent with continued operation of the port function. The extent to which risk minimisation is pursued should not be significantly constrained by consideration of the short-term costs of re-establishing regional service functions in an alternative location.

10. Kokopo is endorsed as the preferred location for the islands regional centre and the Provincial capital for East New Britain

a. Kokopo could be adopted as an alternative centre to Rabaul with a high degree of confidence. This is confirmed by a previous study. In the circumstances further detailed site evaluation is not considered warranted.

11. A significant public-sector led urban development programme comprising relocation of most Government services to Kokopo should be developed

12. The PNG Government should establish an authority or commission to plan and manage the urban development programme efficiently and in a coordinated manner, within the framework of Government decisions on the restoration program. This authority should be legislated by Parliament, structured and managed along private sector lines and have sufficient power, expertise and freedom from excessive regulation,

13. The PNG Government needs to take an urgent decision on moving ahead with such a programme in order to prevent loss of confidence of the general public and the private sector in the future of the Province and of Rabaul-Kokopo as the centre for the Province and the region.

14. Rabaul Harbour should remain the principal sea port and Tokua airport (near Kokopo) should replace Rabaul airport as the hub airport for the Islands Region.

15. The Programme should be given the status of a provincial plan under the Physical Planning Act.

16. Priority tasks for the Authority would be:

i. adoption of an Urban Development Program
ii. development of a structure plan and Stage 1 development plan for Kokopo
iii. development of a financing plan
iv. development of a land management program
v. development of contract packages for construction of infrastructure including:
   - water and sanitation,
   - other services,
   - land development and housing,
   - public/community facilities,
   - commercial and industrial areas and
   - government buildings.

vi. preparation of a Rabaul rehabilitation and land pooling plan
vii. preparation of an institutional development plan.

17. Serious consideration should be given to establishing a Project Management Team for the Authority on an informal basis ahead of formal enabling legislation.

EXECUTIVE SUMMARY

Summary of Damage Assessment

On 19 September 1994 two of the volcanoes fringing Simpson Harbour, Vulcan and Tavurvur, erupted. As a result, Rabaul town has suffered extensive damage to the north and north west of both volcanoes due to ash, and also in the case of Vulcan, due to pyroclastic flows which flattened trees and buildings.

Power and communication facilities have been extensively damaged but water supplies and sewerage may be relatively undamaged. The eastern sector of Rabaul town has been largely destroyed. This sector houses most of the Government facilities, including virtually all the Provincial Government functions. National Government facilities though more widely dispersed, have also been largely destroyed. The majority of port-related facilities are essentially intact, including warehousing, commodity buying, manufacturing and the larger-scale retail enterprises located in the vicinity of the port.

Infrastructure Issues

While the Vulcanological Observatory was only slightly damaged from ash fallout, its capacity to fulfil its prime function of monitoring the behaviour of the volcanoes and to provide timely and reliable reports on the situation has been seriously reduced because of the lack of maintenance, equipment and staffing resources. Given the very real threat of further eruptions which the Observatory may not be able to detect in time it is recommended that:

1. **An urgent programme of support to upgrade the capacity of the Observatory be provided as a specific exercise in the overall disaster reconstruction program.**

    a. This programme includes the procurement and installation of "real time" volcano monitoring equipment and systems.

The report includes an assessment of damage to key Government facilities in a number of sectors and identifies a priority list of projects for implementation in order to restore services and functions as soon as possible. However, it is also stressed that before reconstruction can proceed with any assurance the Government should decide on the issue of relocation, not only in terms of the location but also the functions that should be relocated.

It is estimated that:

2. **The cost of rebuilding facilities and restoring the functions formerly carried out by Provincial and National departments is of the order of K100 million.**

However, this estimate does not include the cost of restoring electricity and telecommunication services and short term assistance to the education sector so that schools can re-open early next year. The cost of restoration of these facilities will be additional to the above figure.

3. **Assistance to the education sector in the form of temporary or permanent classrooms, educational materials and teacher housing is urgently needed so that schools can reopen for the new school year.**

In discussing the impact of the volcano on the buildings and other facilities in the town the report notes that corrosion is looming as an enormous problem for all structures, including houses. It has been determined that compounds formed by sulphates and chlorides in the ash from these eruptions are highly corrosive and that the corrosion will be very difficult to arrest. Most houses have metal roofs,

gutters and rainwater tanks. It is likely that these metal parts now have very limited life unless they are cleaned soon and thoroughly. It may already be too late for many buildings. Drinking water from roof run-off will need to be carefully monitored to ensure that it is safe to drink. In the discussion on damage to a number of the sectors the report stresses that there may be a serious problem arising from the possibility of corrosion of metals by the highly acidic volcanic ash and this needs to be addressed as a priority. The report recommends that:

4. **Priority attention should be given to thorough cleaning of all cables, roofing and other metal surfaces to prevent further damage and the health risks associated with ash should be further assessed:**

   a. this cleaning programme should be based on a technical assessment of the most effective manner by which all chemical effects of the ash and acid fallout can be halted so further corrosion is prevented.

The assessment team noted that in some areas damage to buildings was variable and appeared to relate to design aspects of the buildings. Those with steeper roofs appeared to suffer less damage from the accumulated ash burden than those with flatter roofs. Other aspects of the design of buildings which may have affected the extent of damage were also noted. The report recommends that:

5. **The building code for structures in volcano prone areas should be amended, steeper roofs becoming mandatory. Technical assistance may be required so appropriate standards can be developed.**

During the course of the mission efforts were underway by Provincial authorities to restore access to the town and to specific sectors within the town area through a programme of road clearing. The report notes the importance of allowing residents access to the township and of facilitating the re-establishment of some commercial operations, particularly around the port area which suffered the lightest damage. However, the mission also expressed caution against an extensive programme of road clearing until the end of the wet season. With the coming of the wet season there was significant likelihood that mudflows from the hills surrounding Rabaul could be triggered off by heavy rains and cause greater damage. Until these large deposits of ash were reduced in size or considered to no longer pose a threat it is recommended that the restoration efforts in the town itself and along the main access road from Kokopo should be kept to a minimum.

The report recommends that:

6. **Light industrial areas in Rabaul should be permitted to reopen for business; however,**

   a. Restoration activity in town, including restoration of power, should be kept to a minimum until the end of the wet season.

   b. Work on Kokopo and Burma roads as well as the town roads should be kept to a minimum until the end of the rainy season.

Current situation and Damage Report.

The following sectors were assessed:

Sea Transport

The wharf and wharf buildings suffered little damage. A survey of the harbour floor along the shipping channel revealed little change. The pumice which was restricting ships floated out of the harbour in early November. A complete hydrographic survey of the whole harbour should be undertaken.

Land Transport

The three major roads leading to Rabaul; Kokopo Road, Burma Road and the North Coast Road, have all been damaged, mainly by flooding associated with the impervious ash cover on catchments above the roads.

Roads in the town are probably not badly damaged but they have been covered by ash up to 1.5 metres thick. The removal of this ash will be an ongoing and expensive process for some time yet as flood waters continue to bring down ash from higher areas. All drains in the town are blocked but at this stage there seems to be little point in cleaning them out.

Air Transport

Lakunai airport in Rabaul is covered with a thick layer of ash and the airport buildings have collapsed. The airport has been relocated to Tokua, 45 km to the south of Rabaul, where the existing airstrip, which was already of a reasonable standard, is being upgraded. Access roads and buildings are also currently being improved.

Water Supply and Sanitation

Both water supply and sewerage systems appear to have not been badly damaged. Seismic activity was not significant and underground works are not expected to be seriously damaged. Bore pumps and sewerage pumps are of submersible type and are unlikely to be damaged. The sewerage treatment tank also should operate after it is cleaned out.

Electricity

The two transmission lines leading to Rabaul along the Burma Road/Kokopo Road and the North Cast Road have been damaged by flooding but will not be difficult to repair once the flooding stops. A worrying aspect is the corrosive effects of ash on the aluminium conductors. A suitable method of cleaning off the ash and neutralising its effects must be found.

Telephones

Telikom's facilities have been hard hit in Rabaul. The telephone exchange roof collapsed and the equipment was swamped with corrosive mud. Underground cables, which rely on being under gas pressure to keep out water were depressurised and are certainly damaged by the flooding which followed the eruption. The extent of cable damage however is not yet known.

Postal Service

The Post Office, opened in 1992, has collapsed and has filled with mud. There seems to be

little worth saving.

Radio

NBC's studio in Rabaul has collapsed and its equipment lost. Its transmitter site at Kurakakaul on the north coast is relatively undamaged but corrosion could prove to be a considerable problem in the near future.

Education

Schools on the Gazelle Peninsula have been closed until 1995. Those in and near Rabaul are mostly damaged beyond repair and those outside Rabaul have been converted into care centres and other facilities for displaced people. The Rabaul library is full of mud, its roof is sagging, and it has lost about 75% of its books.

Health

The Rabaul Town Clinic which provided services in dental care, outpatients, mother and child care, nutrition and disease control is extensively damaged. Nonga Base Hospital, which serves as Rabaul's hospital as well as being a specialist referral hospital for the New Guinea Islands Region, is not badly damaged but it is closed due to unreliable supplies of electricity and water. Its functions have been taken over by Vunapope Hospital near Kokopo and the Butuwin Health Centre.

Law and Order

The Court House and Police station are extensively damaged and the large police barracks in Edinburgh Street are completely destroyed. Police staff have either been repatriated to their home provinces or temporarily rehoused at the Tomaringa Police Barracks.

Provincial Government

The Provincial Government owns five building complexes which are all badly damaged.

The largest of these, in Kuanua Street, is repairable but damage to buildings and equipment is extensive. The Casuarine Street complex, which includes the Provincial Assembly building, is also extensively damaged but the assembly building itself is repairable. The Department of Lands and Physical Planning and Department of Forests occupied a complex of buildings in Mango Avenue but these have been destroyed.

National Government

The fire station in Mango Avenue is destroyed. The National Disaster and Emergency Service building in Government Drive is badly damaged as is the National Housing Commission building in Malaguna Road.

The Department of Works owns three complexes in Rabaul; headquarters, supply office, and motor vehicle workshops all of which are in Malaguna Road. Most of the buildings in these complexes have collapsed although there are a few exceptions, notably the paint shop and the

motor vehicle workshop.

The Vulcanological Observatory on Tunnel Hill has not been damaged but some of its equipment and instruments, which were in the town or near the volcanoes, have been lost or damaged. The replacement of instruments, which will give instantaneous information on ground deformation, must be given the highest priority.

Commercial Premises

The team did not assess damage to commercial and industrial premises. However it did note that in Malay town the trade stores and warehouses are devastated. In Mango Avenue the commercial and retail premises are extensively damaged while at the western end of Malaguna Road, where ash fall was light, the industrial and light industrial buildings have been less affected.

Housing

It is estimated that about 80% of the houses in Rabaul are either totally destroyed or will require major reconstruction. Most of the remaining 20% will require at least some work.

Based on the above assessment and taking into account the recommendations made below regarding decisions on relocation the report has identified a priority list of projects and it is recommended that::

7. **The PNG Government should immediately begin implementation of the priority list of projects after a decision has been made on the relocation issue.**

This project listing is as follows:

Sector/Project Name	Project Number	Indicative Cost
Land Transport		
Kavavar Kurakakaul Road Upgrade	R1	K1.5 m
ELCOM housing	R2	K2.5 m
Rabaul town access	R3	K0.5 m
Rabaul Town Road Rehabilitation	R4	K7.0 m
Kokopo and Burma Road Rehabilitation	R5	K2.5 m
Air Transport		
Tokua Airport Upgrade (to F28 Standard)	A1	K1.5 m
Mains Electricity for Tokua Airport	A2	K.03 m
Generators for Takua Airport	A3	K0.1 m
Water Bore/s for Tokua Airport	A4	K0.08 m
Navigation Aids for Tokua Airport	A5	K1.0 m
Weather Monitoring Equipment for Tokua Airport	A6	K1.0 m
Radio Equipment for Tokua Airport	A7	K0.6 m
Staff Housing at Tokua Airport	A8	K4.0 m
Maintenance and Stores Buildings at Tokua Airport	A9	K0.5 m

Sector/Project Name	Project Number	Indicative Cost
Control tower for Tokua Airport	A10	K0.5 m
Administration Building at Tokua Airport	A11	K0.3 m
Water Supply and Sanitation		
Generators for bores at Rabaul and Onga	W1	K0.8 m
Repairs to water mains and services	W2	K0.15 m
Water Board office and equipment	W3	K0.3 m
Water Board Stores and Workshop	W4	K0.3 m
Water Board Housing	W5	K.02 m
Cleaning and Repairs to Rabaul Sewerage System	W6	K0.15 m
Rural Water Supplies	W7	K1.2 m
Electricity		
Repair Elcom Transmission Lines	KL1	K5.0 m
Repair Elcom Distribution Lines	EL2	K0.1 m
Remove Ash from Cables, Insulators etc	EL3	K0.05 m
Repair Elcom Office	EL4	K0.8 m
New Elcom Store and Workshop	EL5	K1.2 m
Elcom Housing	EL6	L3.0 m
Consolidate Diesel Generators at Kokopo	EL7	K3.0 m
Communications		
New Telephone Exchange and Business Office	T1	K5.0 m
Electricity Supply to New Exchange	T2	K0.1 m
Water for New Exchange	T3	K0.05 m
New Telikom Stores and Workshop	T4	K0.8 m
New Transmitter Building in Rabaul	T5	K1.2 m
Underground Cables	T6	K3.0 m
PTC Housing	T7	K2.0 m
New Post Office	P1	K1.2 m
New NBC Studio	RA1	K0.5 m
Re-roof Building at Kuakakaul Transmitter	RA2	K0.05 m
Completion of Project - Radio Link to North Solomon	RA3	-
NBC Staff Housing	RA4	K0.6 m
Education		
Community School Temporary Buildings	E1	K1.0 m
Community School Permanent Buildings	E2	K2.0 m
Provincial High School Temporary Facilities	E3	K0.8 m
Provincial High School Permanent Buildings	E4	K1.4 m
Displaced Primary Student Education	E5	K1.8 m
Education Materials and Office Equipment	E6	K1.0 m
Rabaul Technical HS Reconstruction	E7	K1.1 m
Relocate CODE Office	E8	K0.5 m

Sector/Project Name	Project Number	Indicative Cost
Repair Public Library	E9	K0.65 m
Tok Ples Skul	E10	K0.02m
Rabaul Girls Vocational School	E11	K0.4 m
Health		
Assist Immunisation Programme	H1	K0.3 m
Vunapope and butuwin Hospital Upgrade	H2	K0.3 m
Nonga Base Hospital Refurbishment	H3	
Assist Health Education Programme	H4	K0.25 m
Health Impact of Eruption Study	H5	K0.005 m
Butuwin Health Centre Upgrade	H7	K0.33 m
Rabaul Clinic Reconstruction	H8	K0.3 m
Settlement Areas Health Centres	H9	K0.32 m
Regional health Staff Repatriation	H10	K0.01 m
Handicapped Rehabilitation Centre	H11	K0.06 m
Supply of Office and Medical Equipment	H12	K0.5 m
Law and Order		
Tomaringa Police Barracks Upgrade	L1	K2.0 m
Nodup Police Post	L2	K0.05 m
Equipment and Materials	L3	K0.7 m
Reconstruct Rabaul Police Station	L4	K0.7 m
Reconstruct Police Barracks and Malaytown	L5	K4.7 m
Reconstruct Courthouse	L6	K0.6 m
Provincial Government		
Reconstruct Prov. Govt. Complex, Kuanua	PG1	K1.2 m
Reconstruct Provincial Assembly Complex	PG2	K0.7 m
Reconstruct Prov. Govt Vesters Street Complex	PG3	K0.45 m
Reconstruct Lands and Forests Complex	PG4	K0.9 m
Reconstruct Education Complex in Malaguna Street	PG5	K0.35 m
Supply Office Equipment	PG6	K0.55 m
National Government		
Reconstruct National Disaster and Emergency Centre	NG1	K0.08 m
Reconstruct Provincial Assembly Complex	NG2	K 0.03 m
Reconstruction Prov. Govt Vesters Street Complex	NG3	K2.6 m
Reconstruct Lands and Forests Complex	NG4	K0.25 m
Reconstruction Education Complex in Malaguna Street	NG5	K2.0 m
Supply Office Equipment	NG5	K2.0 m
Supply and Install Volcano Monitoring Equipment	NG6	K1.8 m
Restore Government Housing	NG7	K17.0 m

Details of these projects are contained in Chapter 3 of the report.

Policy and Planning Issues

Rabaul is located in a zone of very high volcanic hazard. The first of the three medium level eruptions in the last century occurred before the town was established; the second cost over 500 lives and this eruption has cost five lives and caused major loss of property. Monitoring systems in place are of limited capacity and hazard mapping is in its infancy.

The re-establishment of East New Britain as a prosperous regional service centre depends on decisions made about the location of key provincial and regional functions. The eruption presents the opportunity to put in place an overall settlement pattern which strengthens ENB's regional service role. There are two major options for the PNG Government:

- ignore the risk of future damage to facilities and loss of life by quickly rebuilding Rabaul to preserve the service centre function in the current location;

or

- minimise risk by relocating some of the functions and related population from Rabaul even if this is expensive and if not properly planned could lead to the fragmentation of, or even loss of, the regional service centre function.

The port function will continue to be important as Simpson Harbour is uniquely suited to this. However, by relocating functions which are not directly port-related to an alternative centre, the risk of future disasters will be significantly reduced. Additionally ENB will be in a better position, with more room and a better airport, to cater for the growing service sector while at the same time continuing to cater for port activities from Rabaul Harbour. This approach is more likely to attract donor assistance and is more likely to re-establish long-term investment confidence.

The report recommends that:

8. **Rabaul town should be partially redeveloped and remain as the port for the islands region, with accompanying commercial activities.**

Given the unpredictability in the timing and impact of future eruptions, the pattern of damage from this eruption - variable damage to structures with broadly uniform and light damage to services - does not provide any rationale for a strategy to reduce risk by shutting down particular areas or parts of the town. The most responsible strategy to reduce risk should therefore be based on a transfer of key functions to safer areas through the relocation of facilities.

The report recommends that:

9. **The principle on which future planning should be based is that risk should be reduced to the minimum possible consistent with continued operation of the port function. The extent to which risk minimisation is pursued should not be significantly constrained by consideration of the short-term costs of re-establishing regional service functions in an alternative location.**

The report proposes a number of degrees of relocation (with the associated numbers of population to be resettled) which would yield increasing levels of risk reduction. High priority categories for relocation of Government functions include functions which:

1. are not directly dependent on the sea port,
2. are in the public sector, and
3. have suffered extensive damage.

Activities which are directly dependent on the sea port, which are in the private sector, and which have suffered little damage have a lower priority for relocation. These levels are set out in the table below:

Levels of relocation	Functions relocated	Population relocated	Rabaul population
Rebuild	none	none	17 500
Low	region serving, public sector and extensively damaged	2 100	15 400
Medium	as above plus province serving public sector	3 450	11 950
High A	as above plus non-port related small businesses	2 415	9 535
High B	as above plus non-port related large businesses	3 115	6 420

The public sector should take the lead by relocating all its activities which are not directly related to the port function. The objective is to create as much certainty as possible about the future pattern of development and rely on the private sector to follow and support this pattern. The private sector should be induced, not compelled, to relocate.

Criteria for selecting an alternative location to Rabaul include access to sea and air ports, access for the provincial population, existing infrastructure and land suitability and availability. On the basis of these criteria the report suggests that:

10. **Kokopo is endorsed as the preferred location for the islands regional centre and the Provincial capital for East New Britain**

    a. Kokopo could be adopted as an alternative centre to Rabaul with a high degree of confidence. This is confirmed by a previous study. In the circumstances further detailed site evaluation is not considered warranted.

The preferred approach to relocation is to see the relocation programme as a major project requiring extraordinary funding and dedicated high level political and management skills with a clear distinction between the two being maintained.

The report recommends that:

11. **A significant public-sector led urban development programme comprising relocation of most Government services to Kokopo should be developed**

In order to manage this process of relocation, the report proposes that an authority or commission should be established to develop Kokopo and to rehabilitate Rabaul. The authority would comprise a political board and a project management team organised on corporate lines. It would coordinate both the delivery of donor assistance and the activities of line agencies. It would also direct the work of contractors. It would work to a fixed time frame.

12. **The PNG Government should establish an authority or commission to plan and manage the urban development programme efficiently and in a coordinated manner, within the framework of Government decisions on the restoration program. This authority should be legislated by Parliament, structured and**

managed along private sector lines and have sufficient power, expertise and freedom from excessive regulation,

The report also notes that:

13. **The PNG Government needs to take an urgent decision on moving ahead with such a programme in order to prevent loss of confidence of the general public and the private sector in the future of the Province and of Rabaul-Kokopo as the centre for the Province and the region.**

Consistent with the above:

14. **Rabaul Harbour should remain the principal sea port and Tokua airport (near Kokopo) should replace Rabaul airport as the hub airport for the Islands Region.**

The Authority would develop and implement an Urban Development Programme which would comprise:

- a policy statement setting out areas of agreement between the different levels of government regarding the overall amount, type and timing of development to be accommodated in Kokopo and Rabaul as well as the staging of this development

- a sectoral investment programme covering the amount and timing of inputs from provincial and national agencies (and donor assistance) in support of the broad policy statement. The programme would be revised and updated at regular intervals.

The Programme would serve as the framework within which otherwise separate planning activities for Rabaul and for Kokopo would be undertaken. It is suggested that:

15. **The Programme be given the status of a Provincial Plan under the Physical Planning Act.**

It is recommended that:

16. **Priority tasks for the Authority would be:**

i. adoption of an Urban Development Program
ii. development of a structure plan and Stage 1 development plan for Kokopo
iii. development of a financing plan
iv. development of a land management program
v. development of contract packages for construction of infrastructure including:

- water and sanitation,
- other services,
- land development and housing,
- public/community facilities,
- commercial and industrial areas and
- government buildings.

vi. preparation of a Rabaul rehabilitation and land pooling plan
vii. preparation of an institutional development plan.

If the Authority's work programme is to be kept on time and to budget it will be essential to offer for tender contract packages that are large enough to attract competitive bidding from major contractors. This need not preclude the use of local sub contractors.

Given the urgency of the work to be done and the long lead times involved the report recommends:

17. **Serious consideration should be given to establishing a Project Management Team for the Authority on an informal basis ahead of formal enabling legislation.**

A pro-active approach to land management will be critical to the success of the Authority. A range of skills are involved including those required to implement land price stabilisation, disaster levy and land pooling schemes; housing finance and real estate; infrastructure programming and planning; public relations and community development.

Given the urgency of the work to be done and the long lead times involved, serious consideration should be given to establishing a Project Management Team for the Authority on an informal basis ahead of formal enabling legislation. A pro-active approach to land management will be critical to the success of the Authority. A range of skills are involved including those required to implement land price stabilisation, disaster levy and land pooling schemes; housing finance and real estate; infrastructure programming and planning; public relations and community development.

1. INTRODUCTION

Rabaul, the Provincial capital of East New Britain, has been built on a vast volcanic crater which has three active volcanoes inside it. The enormous crater also forms a safe, natural harbour for the town, and in the hundred years or so since the establishment of the Rabaul the town has grown extensively around the foreshores of this harbour. In recent history, Rabaul has been seriously affected by volcanic eruptions on a number of occasions. In 1937 serious damage and loss of life was caused by a major eruption of the volcanoes; during 1984 a period of very high seismicity and ground deformation was expected to lead to a similar scale of eruptions but, fortunately, this did not occur. Nevertheless, this 1984 experience led to the development of a comprehensive strategic plan for the town, both for evacuation in the event of a major eruption and for longer term regional development.

On 19 September 1994, a volcanic earthquake triggered the eruption of the two most active volcanoes adjacent to Rabaul, Vulcan and Tavurvur. Rabaul was evacuated during the course of the following two days and people moved to safe shelter points in the nearby settlements, principally in the area around the nearby township of Kokopo. A State of Emergency was declared and assistance was requested by the PNG government for shelter, food and water for the affected populations, which were estimated to number up to 100 000. The volcanic activity continued for a number of days after the initial eruption then gradually started to diminish, allowing authorities to commence some clean up operations and restoration of access to areas within the township. Some damage assessment of buildings and facilities has commenced but there was a need to assist the authorities in the Province undertake a more comprehensive assessment of the extent of the damage and to identify priority areas and needs for reconstruction.

The Australian Government and other donors quickly responded to the disaster with emergency supplies and the provision of emergency air transport. Close liaison was developed between AIDAB and the Provincial authorities in the identification and delivery of this assistance. In terms of the longer term needs an offer to assist in the needs assessment for the reconstruction programme was made by AIDAB.

The AIDAB needs assessment mission, whose findings are contained in this report, visited Rabaul in October/November 1994. It represents the first stage in the development of a long term programme for reconstruction and rehabilitation support, from Australia and other donors, for the reconstruction of New Britain Province.

The objectives of the mission were to:

- assess and document the damage
- identify projects, technical assistance, and other needs
- analyse relocation issues and relate the findings to the proposed projects.

The mission's team comprised three members:

- Mr Max Blacker, Team Leader/Engineer
- Mr Bob Patterson, Engineer
- Mr Des Hoban, Regional Planner.

Mr Kukuo Sakamoto, JICA adviser to OIDA joined the team for the latter part of its stay.

The team acknowledges the valuable and considerable input from Mr Bill Costello of AIDAB in Port Moresby and Mr Joel Luma of PWD. Without their groundwork and organising skills the team would not have covered nearly as much ground.

Current AusAID Minister-Counsellor

The report sets out details of damage to government sector assets and suggests projects which will restore the functions formerly carried out by each department.

It addresses the issue of Rabaul's relocation. It recommends that the town be relocated to Kokopo and sets out reasons for this. It states that, most importantly, the relocation issue must be resolved quickly and firmly and that the government must take the lead role. The report sets out the steps which must be taken to settle the relocation issue and suggests methods of reconstruction which will maintain a healthy momentum and attract the required level of donor funds and participation.

This report does not claim to cover every issue in every sector. It attempts to bring together the available information, supplement it with the assessment team's own findings, and present a report which can be used as a basis for technical assistance and donor and government funded projects in the respective government sectors.

2. THE ERUPTION AND IMMEDIATE RESPONSE

2.1. THE ERUPTION

The 1994 event commenced with the almost simultaneous eruption of both Tavurvur (0605 on 19 September) and Vulcan (0717 on 19 September). The eruptions were preceded by 27 hours of vigorous and fluctuating seismic activity, beginning with a magnitude 5.1 caldera earthquake at 0250 on 18 September. In the week leading up to the eruption there was no unusual inflation of the ground surface in the harbour area, but there was inflation and local uplift of as much as 6 metres overnight 18-19 September. This was not known until first light on the 19th.

The eruption of Tavurvur commenced with emission of vapour at 0605, and was followed by moderate to strong emission of ash through the following week. This eased slightly on Saturday 24th and continued to ease through the following weeks. During the second week of the eruption, as the rate of emission decreased, it became apparent that a lava flow had developed within the crater. This emanated from a vent west of the main vent and flowed down the sloping crater floor to the west. By late October it had progressed part way down the western slope of the cone.

The eruption of Vulcan began with a mild emission of pale brown ash and pumice at 0717, followed within about 30 minutes by very strong, near-continuous explosions that sent an emission column to at least 20 km above sea level and distributed pumice fragments over the entire Rabaul area, extending as far south as Tomaringa, Livuan and Vudal. Eruptions of Vulcan were from both the 1937 crater and from a new vent that developed immediately to the north east. There were also emissions from blastholes on the south west side of the 1937 cone. Eruptive activity included lateral flows of pumice, ash and hot gases that extended for at least two kilometres in all directions. Pyroclastic flows across the surface of the harbour were mistakenly reported as indications of development of new eruptive centres under the harbour. Tsunamis up to 2-3 metres high were generated in the harbour after the eruption started on the morning of the 19th, and oscillations of sea level of up to half a metre amplitude continued through the 19th.

Moderate explosive activity at Vulcan continued until 24 September, and mild activity until 2 October after which time there was only weak steaming from the bottom of the new crater.

At the end of October Vulcan had been dormant for almost four weeks and Tavurvur was still erupting but with diminished energy and lower frequency of explosions.

2.2. THE EVACUATION

In the light of the continuing earthquake activity, the Rabaul Vulcanological Observatory recommended the declaration of a stage 2 alert at 1800 on Sunday 18th. This was declared at 1815. Through the late afternoon and evening a voluntary evacuation of the town developed. At midnight the RVO advised the Provincial disaster Committee that an eruption was imminent. By this time townspeople had congregated in Queen Elizabeth Park. Transport was organised and through the hours from midnight onwards people were ferried from the town area to beyond the caldera rim, at Vuvu or beyond. The RVO recommended a stage 3 alert in the early hours of the morning but the Disaster Committee refrained from declaring a stage 3 alert because the evacuation appeared to be proceeding smoothly. It was feared that announcement of a higher stage of alert might be counter-productive. In the event the evacuation went smoothly and by around 0700 on Monday 19th the town and high risk areas were virtually deserted.

2.3. CURRENT RISKS

Two major dangers still threaten Rabaul and the surrounding area.

One is the possibility of further eruptions. Tavurvur, at the beginning of November, is still erupting mildly and is emitting substantial quantities of ash. This level of activity has been maintained for several weeks.

There is some concern that it is not abating as was expected and although there is nothing to indicate further eruptions, a very real threat lingers. The Rabaul Observatory's current equipment cannot give the instantaneous information on ground deformation that is necessary to properly monitor the situation. Procurement of such equipment must be given the highest priority.

The other major danger is from mud slides and flooding due to ash deposits on the steep areas above Rabaul and other nearby villages. The danger of mud slides in the form of huge moving masses of mud seems unlikely. The ash is more like wet sand than mud and erodes and breaks up very easily. The more likely result from heavy rain is flash flooding. The ash has formed a near impervious layer over the catchments and water is not retained by soil and vegetation as it was before. Most of the rain that falls therefore runs downhill immediately and rapidly, taking ash with it by erosion.

Whether the damage is from mudslides or flash flooding is academic as the results are similar for both. The ash will eventually stabilise after the bulk of it washes to lower areas and rest is held in place by the vegetation which is already reappearing. It is expected that some sort of equilibrium will be reached after the end of this wet season but there will be vast amounts of material to be cleared from the lower areas.

There is also the possibility of disease outbreaks in the overcrowded care centres. However that has so far not been a problem and the populations of care centres are diminishing as people return to their home provinces.

2.4. CLEAN-UP ACTIVITIES

Almost all roads in and around Rabaul were open during the assessment team's visit. This is due to the efforts of local contractors and Department of Works under the direction of the Disaster Committee. In particular, Mr Steve Day of East New Britian Quarries and his staff have moved an enormous amount of material. It is expected that it will become increasingly difficult to keep all roads open during the rainy season (November/December) as ash from the steep areas above the town is washed down but the Committee has decided that generally it will try to keep the town roads open. Cleaning out of commercial premises in the lightly affected western part of Rabaul is well underway but work in other areas has been limited to salvaging contents of buildings.

Apart from clearing of ash from the ground there is the enormous task of cleaning it from the roofs, walls and floors of buildings and from other structures and items such as masts, overhead cables and insulators. There has been little done yet in this area and it is unclear as to whether simple cleaning with implements and/or water will be enough. The ash is corrosive and specialist advice should be sought as to the best methods of cleaning and treatment. Specialised equipment is also likely to be required. Such advice and equipment is a worthwhile project for donor funds, particularly for the cleaning of overhead electricity cables and insulators.

The disposal of damaged building materials and contents has not yet been addressed as most clean up activity so far has been the removal of ash from roadways. The current dump site at Sulphur Creek will probably continue to be used for rubbish as there seems to be no alternative. It is tempting to say that the impact of rubbish disposal, compared with the devastation caused by the eruption, is insignificant but the disposal of some items such as industrial wastes and the contents of refrigerators and coldstores will have a long-lasting effect. Specialist advice would be helpful.

3. CURRENT SITUATION AND DAMAGE REPORT

The extent of defoliation and ash deposits is shown in Figure 1.

The depths of ash deposit from Tavurvur are shown in Figure 2.

Depths of ash from Vulcan have not been measured but there is evidence that it is 3 metres or even more in some places.

3.1. SEA TRANSPORT

Before the eruption Rabaul was the third largest port in Papua New Guinea with a throughput of 320,000 tonnes in 1993. The Harbours Board wharves were valued at K20 million. The harbour was closed after the eruption and not reopened until a survey was undertaken to ascertain any changes to the profile of the harbour floor. The results of the hydrographic survey, which found little change to the seabed inside the harbour, were available on the 24th October and the harbour reopened on the 25th. Pumice floating on the harbour hindered ships because it blocked their water intakes and abraded their hulls. However, on 2 November the wind changed to the north east and within a day or two most pumice had left the harbour. From the eruption until October ships up to 1 800 tonnes were able to use Kabakaul Wharf near Kokopo, but it had difficulty handling the heavy traffic and delays occurred. Shipping of limited quantities of cocoa for export via Lae was undertake from Kabakaul Wharf but it is not safe to use when the north west winds begin in November. The Harbours Board has relocated its staff to houses in Kokopo.

The Harbours Board wharves do not appear to have been damaged. A detailed structural investigation is scheduled to be carried out in the week beginning 24 October 1994. There is one night beacon on Dawagia Rocks but its condition is unknown. There are two navigational pointers on shore. No night work is possible until the town electricity or backup is provided. An auxiliary electricity supply was provided for security lighting and office use from 26 October. Ships will not be able to load water at Rabaul until the water supply has been reinstated. Little or no structural damage is evident to the storage sheds.

The Coconut Products Limited (CPL) wharf has been affected by silting adjacent to the structure. The company intends to use high pressure air hoses to spread the silt. If this does not work some dredging may be required to make the wharf useable.

3.2. LAND TRANSPORT

At the time of the assessment team's visit all access roads to Rabaul were open with the exception of Namanula Road linking Rabaul with the north coast.

Flooding has damaged the Toleap to Kerevat Road at Vuvu where approximately 50 metres of road is eroded away to a depth of 2.5 metres. There is minor damage to gravel roads in the Reimber Community area west of the Burma Road. The drainage systems on the Iatapal to Vunairima Road and Kavavar to Kurakakau Road are affected by ash fallout is some minor drainage systems becoming blocked. The Vunalaka to Kurakakaul Road was affected by ash deposition and severe erosion associated with increased runoff. This road was closed for over a week after the eruption and may again be affected by erosion associated with increased runoff due to the layer of ash. Other minor roads in the Reimber Community are also affected by ash fallout ahd will require remedial work. Continual erosion and blockage of culverts may occur on all these roads after heavy storms until the ash stabilises. Minor maintenance was undertaken on the Vunavuting to Ramale road due to the eruption.


Tavui Point
Vunakulakum Mission
Naono Plantation
Undtekeimeme Plantation
Tavui No 1
Ramabagaus Mission
Namale Mission
Tavui No 2
Lamantu Plantation
Takudukudu Mission
Coconut and cocoa
Tavui No 3
Nonga Plantation
Nonga
Tomatikolop Reef
Lowea Point
Karere (aid post)
Ulalai Mission
Tokaboi Mission
Balanatanian Creek
School
Volavolo (school)
TOYANUMBATIR (NORTH DALIGETTER) (extinct volcano)
Rabuana
Ratavul
Volcanological observatory
Pugeo
Bakunai Ck.
Pilapila (school)
Malaguna No 1
Oval
RABAUL
Oil tanks
Lookout
Ratung
Kurakakaul Oval
Vuvu Mission
Iawakaka
Malaguna No 2
Simpson Harbour
Sulphur Creek
Golf course
Cemetery
RABALANAKAIA CRATER
KOMBIU (THE MOTHER)
Vunakomkombi Plantation
Vuvu Plantation
Mission
Malaguna No 3
Lakunai Aerodrome (Rabaul Airpor
CRATER PENINSULA
Dawapia Rock (The Beehives)
Ropopo
Matupit Harbour
Bridges Point
Causeway
MOUNT TAVURVUR
Cemetery (MATUPI CRATER)
(last eruption 1941)
Matupit No 2
Matupit No 1
Matupit Island
Lava
Sulphur Point
Kalkalulu
Taranga
Kuraip
Raluan No 1
VunaVavar (school)
Raburbur
Raluan No 2
Vunalaka
Tavana
VULCAN CRATER
(last eruption 1937)
Vulcan Point
Reimbel
Latlat
Rakunai
KOKOPO ROAD
Kakandukondo
School
Navuneram
Tavuiliu
Karavia No 1
HIGH RISK AREA
RABAUL VOLCANO DISASTER
NEEDS ASSESSMENT MISSION
EXTENT OF DEFOLIATION
AND ASH DEPOSIT
FIGURE 1



RABAUL VOLCANO DISASTER
NEEDS ASSESSMENT MISSION

DEPTH OF ASH DEPOSITS FROM TAVURVUR (DEPTH IN MILLIMETRES)

FIGURE 2

The Kokopo Road from Tavuvutavur Catholic Mission to south of Tavana village, a distance of approximately 7 kilometres, is covered with tephra to a depth of 1 to 2 metres. In addition the road is severely eroded in two places between the Burma Road intersection and the Tavuvutavur Catholic Mission. The road becomes impassable after rainfall of 10 to 20 mm. This situation is likely to continue for some time, probably months. Similarly the Burma Road is affected for a length of approximately 2 kilometres from its intersection with the Kokopo Road. The road is open in late October but closures are expected after rain for some time to come.

Most of the town roads in Rabaul have been made trafficable by removing tephra from the carriageways but the stormwater drainage system in the town is not functioning and closures will occur after rain Tephra is being dumped near Sulphur Creek..

Most of the tephra in Malaguna Road has been removed from between the Tunnel Hill and Kombiu Avenue intersections and it is expected that it will not be difficult to keep open, even after storms.

Most residential roads to the west of Wisdom Street are now clear of tephra but may experience blockages after storms.

Little structural damage has occurred to the pavement either during the eruption or subsequent flooding but some bituminous seal has been damaged by machines during the clean up.

Rainfall of 40mm one night during the team's visit closed all roads in the town and several days work was required to make them trafficable again.

Evidence of fine alluvium being transported in suspension by stormwater was found in a number of buildings. This material forms a fine dense mud which cannot be flushed out of underground pipes. It must be physically removed, but this is an almost impossible task with small diameter pipes. Fortunately most of the stormwater system in Rabaul consists of open, lined drains which will be easy to clean.

The Kokopo to Tokua Road is being upgraded by widening, sealing and generally improving the horizontal alignment for its eastern 7.3 km. This work is being done to accommodate the increased traffic volume generated by Tokua Airport. The work is scheduled for completion in the first week in December. Approximately K0.5m of the estimated cost of K1.33m has been spent by late October. The IBRD is funding 64% of the cost of the work.

Generally all main roads in the Gazelle Peninsula are very busy with heavy traffic flows. No bridges have been affected by the eruption to date. However, the situation at the two major wash outs on the Kokopo Road at Malaguria and the one on the North Coast Road at Vavu will need to be reassessed after the catchments stabilise. It may be necessary to install bridges, or at least major culverts at these sites even though none existed before.

3.3. AIR TRANSPORT

Airports and air movements are under the control of the Department of Civil Aviation (DCA). It controls two airports in the Rabaul area:

- Lakunai Airport at Rabaul
- Tokua Airport 45 km by road SE of Rabaul

Vunakanau airstrip 20 km SW of Rabaul has been de-licensed.

i. Lakunai Airport, Rabaul

This airport is currently unusable. It was covered with a layer of ash approx 0.7 m deep from Mt. Tavurvur, which is about 3 km to its south-east, but it seems certain that this depth has increased to about 1.0 m due to ash being carried onto it by flooding from higher areas. Six weeks after the main eruption it was also still receiving occasional measurable deposits of ash from Mt. Tavurvur.

The runway's pavement consists of a coral base surfaced with a bituminous seal. Its condition is unlikely to have been affected by the ash itself but later flooding could scour out strips below the original surface level similar to what has already happened in other areas, especially north of Vulcan.

All airport buildings have been subjected to heavy ash loads. Most have collapsed and are damaged beyond repair.

They include - the Terminal Building (900 sqm), which has completely collapsed

- DCA's administration building (400 sqm) which is still intact but the roof and ceiling have sagged
- the fire engine building (250 sqm) which has a partly collapsed roof
- 7 storesheds and workshops (total about 1,500 sqm), all of which have collapsed
- 2 generator sheds which are bent but still standing
- 30 houses and residential quarters. Of these only 10 remain standing in the lesser affected parts of the town, 8 north of the wharf and 2 in the Tunnel Hill area, but even these have been vandalised.

At the airport there are also 3 airline offices, Air Nuigini's cargo building and two hangars belonging to Airlink and Island airlines. These buildings have all collapsed.

Four aircraft and a number of cars are also buried under ash. Two helicopters were stranded at the airport during the eruption. They have since been recovered but it is reported that they will probably not fly again due to corrosion of mechanical parts.

Equipment which has been lost includes the taxiway lamps and the non directional beacon which are buried under ash. DCA believes they are not worth retrieving, mainly because they will be corroded. The assessment team has witnessed the corrosive effects of the ash in many places and agrees that chances cannot be taken with such important safety items. Two rollers and two tractors were inside the airport maintenance building when it collapsed. It is not known yet whether they are recoverable, but is seems unlikely.

Equipment which has been recovered includes the domestic and international distance measuring equipment (DME). Both items were at the Observatory. It is hoped that the domestic DME will be functioning at Tokua by the end of October. DCA staff are also attempting to retrieve three generators (2 from the airport and 1 from Tunnel Hill) and are optimistic that they will work.

Lakunai airport, even before the eruption, was not without its problems. The caldera rim to the north-east and Tavurvur to the south-west restricted its use to F28 standard, and even that required special dispensation. Suggestions of a soft area in the runway, perhaps associated with a spring or volcanic activity were conveyed to the assessment team. The bituminous seal on the runway apparently bubbled soon after

rain, which suggests a simple drainage problem, but the team has not been able to confirm or deny its existence or cause.

Lakunai airport was used as a hub for smaller airfields including Buka, Namatanai etc. Both Airlink and Islands airlines based planes at Rabaul.

ii. Tokua Airport

This airport is 45 km by road south-east of Rabaul. It was not damaged by the eruption and it has now assumed the role of Rabaul's airport, a role which it is certain to retain.

The Department of Works, using its own forces and subcontractors, is upgrading the eastern 7.3 km of the access road to the airport, resheeting and sealing the runway, including taxiways and aprons, and constructing car parking areas. The roadwork includes some major realignment, bituminous surfacing and a significant stream crossing. By late October 94 clearing for the road is complete and the road formation is well under way. The taxiways, aprons and car parking are also well advanced. Construction of buildings to accommodate a temporary terminal, air control services, administration and fire services have commenced. The airlines are also constructing temporary offices and shelters to replace the current makeshift shelters.

The airport is, in late October 94, handling about 60 movements per day, after having reached a peak of 242 movements soon after the eruption. It is expected to rise again to about 70 movements per day which is similar to that of Rabaul airport before the eruption. It is a credit to the 25 relief DCA staff that the airport is operating smoothly. They are working and sleeping in makeshift shelters, and operating with pieces of equipment salvaged from Rabaul.

There is a desperate need for accommodation. DCA's 65 local staff are on leave until the end of 1994, but if there is no housing available then it is unlikely that they will be able to return. Their options will be the already overfull private housing or overcrowded care centres.

3.4. WATER SUPPLY AND SANITATION

3.4.1. Water supply, Rabaul

Rabaul's water supply system consists of seven bores with submersible electric pumps, one 100,000 litre tank to the north of the town and 6 x 45,000 litre tanks spread around the town. The water from the bores is distributed, via a piped system linking all bores, to about 1,600 metered customers. The system is controlled by the Water Board, a national government statutory authority. Many residents also have their own tanks fed from roof runoff but these are used for drinking water only. The corrosive nature of the ash will mean that the water currently held in tanks is undrinkable and that roof runoff will also be undrinkable until the roofs and gutters are thoroughly cleaned or replaced. Most tanks are galvanised steel and are already corroding badly. Most will need to be replaced.

The current situation is that two bores (in Blanche Street and at the Elcom Power Station) have been isolated from the mains system and by using generators they are able to supply water for mobile tankers. The water from these bores is uncontaminated, which is cause for optimism for the rest of the system.

The earthquakes accompanying the eruption were relatively minor so it is unlikely that the underground reticulation mains suffered any serious damage, however the Water Board has already pumped water

into the system and it leaked in many places. It has not yet been possible to identify these leaks but it is probable that it was a combination of taps left on, services or fittings broken during clean up operations and leaking ball-type hydrants. These hydrants rely on water pressure to hold the balls in place. When pumps on the bores stopped working and pressure dropped in the mains, the balls dropped and allowed ash to enter the hydrants. This ash now prevents the balls from returning to their seats when the mains are recharged. However, the possibility of damaged mains cannot be completely discounted.

It is also likely that the pumps and electric motors will operate after they are cleaned and/or reconditioned.

Buildings:- The Water Board did not own an office in Rabaul but its rented premises collapsed and some records were lost. It owns a workshop/store which collapsed and some tools and equipment were lost, but pipes and fittings are mostly undamaged. These items are being retrieved and placed in a container for transport to Kokopo. A shed adjacent to the store is being dismantled and taken to Kokopo, where it will be reassembled and used as an office. The Water Board owns two houses in Rabaul. Both of them have collapsed.

3.4.2. Water supply, Keravat, Nonga and Kokopo

These water supply areas have about 50, 250 and 300 customers respectively. The only effect of the eruption has been interruption to electricity for the bores' pumps. At Nonga, generators have been used but there has been some reliability problems.

3.4.3. Sewerage, Rabaul

Most of Rabaul is serviced by septic tanks with the reticulated sewerage system, controlled by the Water Board being confined to an area near the Mango Ave commercial area. It consists of a piped system, with the main pipe along Mango Ave, three pumps and an Imhoff tank which discharges into the sea. The tank needs cleaning out but appears to be otherwise undamaged and the outfall also appears to be undamaged. Like the reticulated water system it is unlikely that the underground pipes are damaged, but ash and mud has probably already entered the system and during reconstruction of the town it is inevitable that some rubbish and mud will enter the pipes and cause blockages.

Septic tanks should not be damaged and it is expected that most will operate without any further attention.

A map of the main sewerage lines is shown in Figure 3.

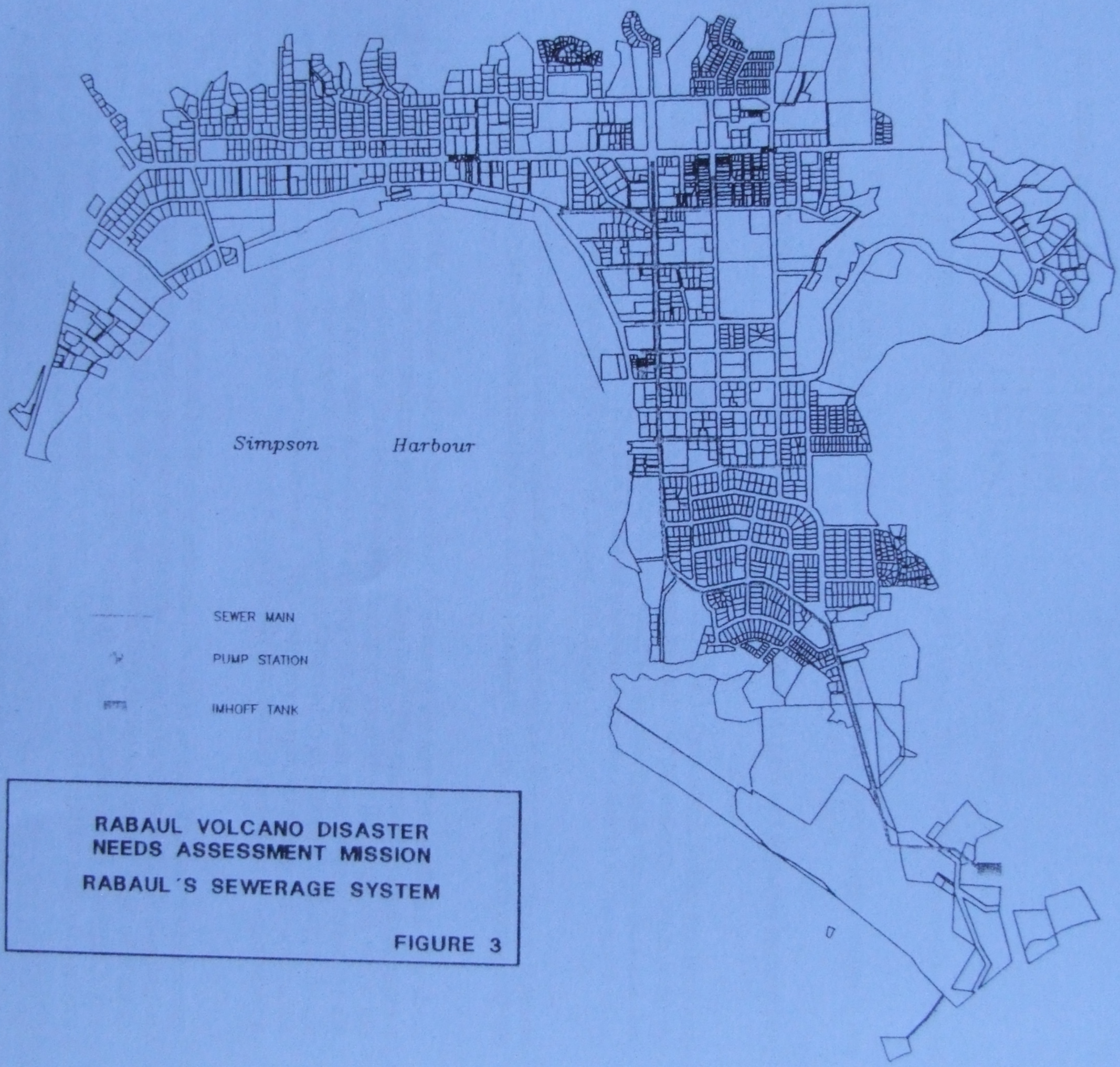
3.4.4. Sewerage, other areas

Nonga hospital has its own sewerage treatment plant which is apparently undamaged but the hospital is not in use in late October.

3.5. ELECTRICITY

Electricity for the Gazelle Peninsula is generated and distributed by ELCOM, a national government statutory authority.

There is currently no electricity in Rabaul, but it is available in all other areas including the Rabaul Observatory. Supply to the north coast and the observatory have been somewhat unreliable because of ash and associated flooding which is continuing to damage both transmission and distribution lines in that area.



SEWER MAIN

PUMP STATION

IMHOFF TANK

RABAUL VOLCANO DISASTER
NEEDS ASSESSMENT MISSION

RABAUL'S SEWERAGE SYSTEM

FIGURE 3

3.5.1. Generation, transmission and distribution

Electricity for the Gazelle Peninsula, including Rabaul, is generated at three locations :-

(i) Warangoi Hydro Station	2 x 5 MW generators,	Total 10.00 MW.
(ii) Kerevat Power Station	1 x 1.2 MW 1 x 0.45 MW,	Total 1.65 MW.
(iii) Rabaul Power Station	1 x 0.45 MW 3 x 0.65 MW 2 x 1.0 MW 1 x 3.0 MW,	Total 7.40 MW

The two 1.0 MW generators in Rabaul are containerised and leased. The 3.0 MW generator in Rabaul is mobile.

The Rabaul Power Station is in the least affected part of the town. Ash cover is light, probably less than 50mm and the equipment and buildings are intact. Cleaning is in progress.

Substations and transformers are distributed around the town. Most of these will probably operate after they are cleaned. The units are all sealed and oil filled.

The three generator locations are linked by both 66 KV and 22 KV lines which follow similar routes except between Navuneram (12 km south of Rabaul) and Rabaul. At Navuneram, which is on the caldera rim, the 66 KV line continues down along Burma Road to the coast inside the caldera and then follows Kokopo Road into Rabaul. The 22 KV line heads away from the caldera to the north coast, which it follows before returning to Rabaul via Tunnel Hill Road.

Both transmission lines have been damaged, but the 22 KV line, which is outside the caldera as it passes Vulcan, was not badly damaged and electricity was quickly restored to much of the north coast and the Rabaul Observatory.

The 66 KV line is badly damaged near the intersection of Burma Road and Kokopo Road. For about 2 km its poles are leaning and unstable and one pole has fallen over. The cause of this damage appears to be not directly from the volcano, but from flooding during or soon after the eruption which has eroded material from around pole bases and stays. It is likely that the high runoff was because the ash cover prevented rainwater from soaking into the ground and vegetation as it normally does, although unusually heavy rain may also have contributed. The relatively impervious ash still covers the catchments above the damaged 66 KV line so it is highly likely that further damage will occur when it rains.

The 22KV line has also been damaged by flooding although it is not as severe. The ash cover extends outside the caldera and severe erosion has occurred along the north coast where the 22 KV line passes. At one point, near St. Mary's school at Vuva, a pole which was previously on the edge of a small erosion gully is now in the middle of a large gully. Although it has dropped about 2 metres it has remained vertical and is continuing to support live wires. However, this pole, together with a few others nearby on the same line, are vulnerable to further flooding.

The transmission lines, as well as distribution and service lines, were coated with sulphurous volcanic deposits, especially early in the eruption. These sulphurous deposits, mixed with water, could result in the formation of corrosive sulphuric acid. There are presently no obvious signs of abnormal corrosion, but samples of ash and aluminium lines should be tested as soon as possible to determine what measures, such as cleaning or chemical treatment, should be taken. About 35 km of multi-cable

transmission lines are affected by ash deposits. A plan of the transmission line network near Rabaul is shown as Figure 4.

Distribution lines in Rabaul are mostly undamaged except for the effects of possible corrosion described above. There are a few wires and crossarms broken by falling trees and at least one pole is broken off at the base, probably by street clearing operations.

A surprisingly large number of service lines are still connected to buildings, even to buildings which have collapsed. However, they have been subjected to stresses, and for safety reasons will need to be renewed during reconstruction. There is a need for a foolproof system of wiring checks and certification before premises are reconnected to the distribution network. The team was told that Elcom had already reconnected supply to an area of Rabaul for a short time recently and a pump motor in the informant's unoccupied house had burn out. This illustrates the importance of the need to check first. The risk of fires from such causes is great.

3.5.2. Offices

The District Office, a two storey building of approx 200sqm roof area, is repairable although repairs will be extensive. The major item is the roof. It has not caved in but it is badly deformed and must be replaced. Mud has entered the lower floor.

The large corrugated iron 1,100 sqm warehouse behind the district office is misshapen and partly collapsed. It is not worth repairing.

3.5.3. Housing

ELCOM owns 35 houses and duplexes in Rabaul in which it housed its staff. Seven houses near to the Power Station are only slightly damaged but of the remaining 28, all have collapsed roofs and most have collapsed walls.

3.6. COMMUNICATIONS

Communications covers Telephones, the Postal Service, Television, Radio, and Newspapers.

3.6.1. Telephones

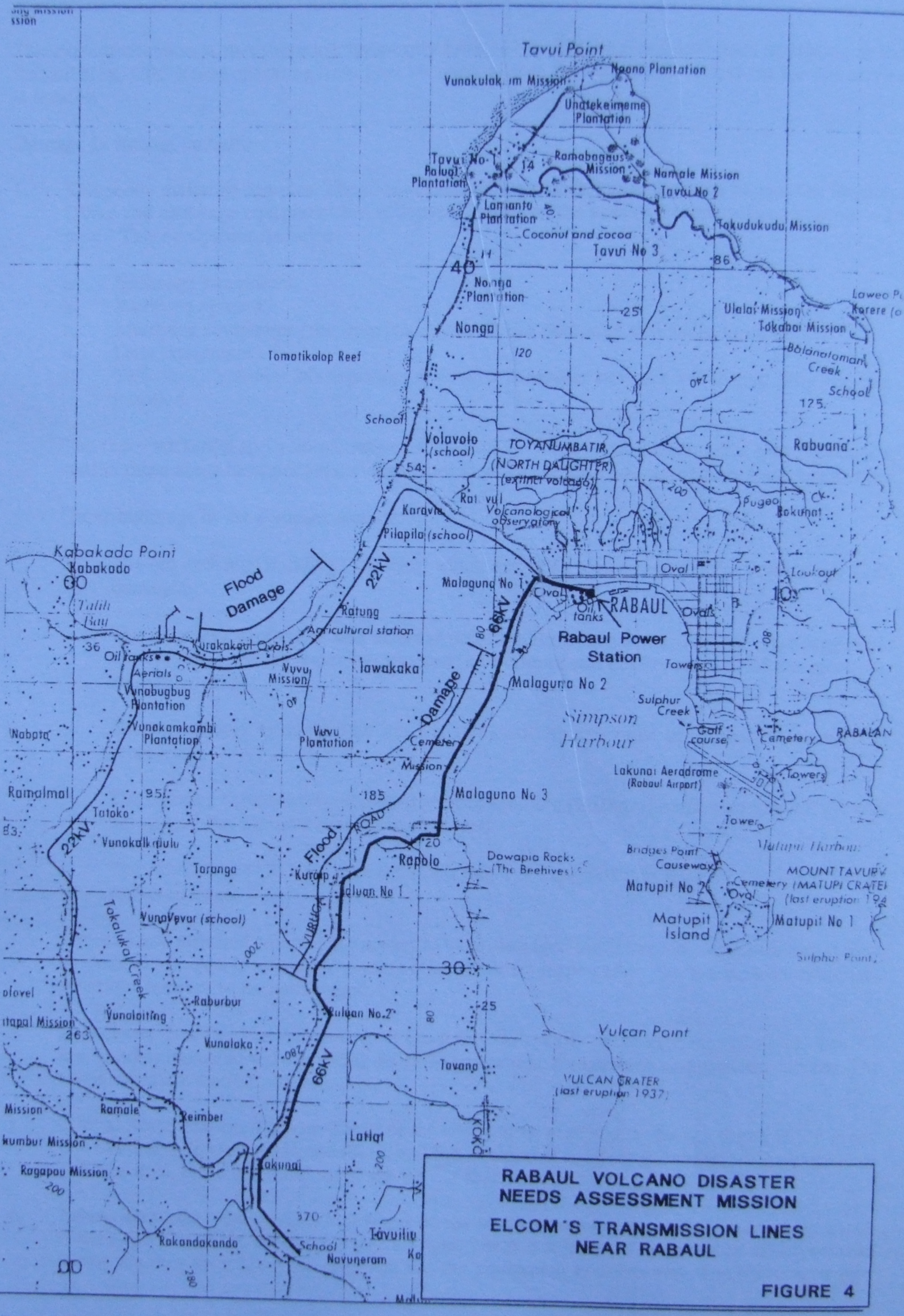
The telephone system is controlled by Telikom, a National Government statutory authority, under the umbrella of the Post and Telecommunication Corporation.

The telephone system in the affected area consists of the following elements:

a. Local calls are conveyed via cables between Rabaul, Toleap and Nonga Hospital, and by microwave links through the Tomavatur repeater station (about 21 km south of Rabaul) to Keravat and Kokopo. There is an additional cable network between Tomavatur and Tomaringa (about 14 km south of Rabaul)

b. Long distance and international calls are transmitted via a microwave link from Lae to the repeater station at Tomavatur and then a further microwave signal from Tomavatur to the Rabaul exchange.

c. Coastal Radio Service (CRS). This service allows ships to be connected to the telephone service via the Rabaul exchange.



RABAUL VOLCANO DISASTER NEEDS ASSESSMENT MISSION

ELCOM'S TRANSMISSION LINES NEAR RABAUL

FIGURE 4

The current situation is that there are temporary links set up for the few telephones operating in the Rabaul area. CRS is now operating from Port Moresby, where the only other equipment for this service is located.

Damage in Rabaul includes

1. Telephone exchange complex. The roof of the 1100 sqm main building which houses the Business Office and exchange equipment has collapsed, covering the sensitive electronic equipment with mud. This equipment includes:

   a. Exchange equipment
   b. Radio equipment
   c. Multiplex equipment (the interface between the exchange and radio equipment)
   d. Data equipment
   e. Telikom's Customer Management system, a computer network which had only just been installed.

   The radio workshop and administrative office are also in the main building but some sections of roof in these areas have not yet collapsed and most of the files and equipment have been saved.

   Other buildings in the complex include:

   - The old exchange building (350 sqm) which was been converted to offices and is not badly damaged.

   - The customer equipment and external plant building (170 sqm). The roof has sagged but has not collapsed but water has entered the building and destroyed most of the electronic equipment inside.

   - The main stores building (400 sqm) is still standing and most of its contents have been recovered

   - The building department and property office building (110 sqm)is still standing but the roof has sagged. Its contents have been retrieved.

   - The cable shed (170 sqm) has collapsed but it is expected that most of the cable will be retrieved intact.

   The mast and attached equipment appears to be undamaged but it has a coating of ash that must be cleaned off. Ash is already corroding other facilities inspected by the team. A containerised generator appears to be undamaged.

2. Transmitter site. This site in Tavur street has suffered similarly to the exchange complex. The 300 sqm building has collapsed destroying the radio equipment, transmitters and generator inside. The seven masts are coated with ash.

3. Coastal Radio Station. The site is east of the wharf in an area where the ash depth is not great. The building is in reasonable condition, and the equipment inside it is unharmed. As with other Telikom sites, there is a build up of ash on the four masts.

4. Tolcap Exchange building. This building is on the north coast near the end of Tunnel Hill Road. It has a covering of ash but is otherwise all right. There is some mud on the floor, which entered during flooding soon after the eruption, but the equipment is unharmed. The building is now

sandbagged to protect it against future flooding.

5. Housing. PTC owns 18 houses, 4 flats and a 23 room hostel in Rabaul. The only buildings not destroyed are two houses at the Post Office and two at the Coastal Radio Station.

6. Underground cables and pits. There are underground cables in Rabaul town, between Rabaul and Toleap and between Toleap and Nonga Hospital. The cables are paper or plastic coated and are protected against water by being contained in a sheath which is pressurised with gas. If a leak develops, gas pressure stops water from entering the sheath. Water corrodes the cables and causes cross connections or failure. The cables are particularly vulnerable at the many joins, and in the case of paper covered cables, over their entire length. Gas pressure was lost during the eruption so it is certain that water has now entered the cables. The extent of damage is not known and cannot be determined until the cables are tested.

3.6.2. Postal services

Postal Services are operated by Postal, another statutory authority under PTC. Its modern Post Office in Rabaul, opened in 1992, is completely destroyed. The entire roof on the 600 sqm building has collapsed and mud extends to about 2/3 of the height of the counter. There seems to be little to salvage in this building.

3.6.3. Radio

The National Broadcasting Authority, NBC, broadcasts national and local radio programmes. It maintains a studio in Rabaul and a complex of masts and associated equipment at Kurakakaul on the north coast.

National programmes are received at the Rabaul studio and then sent by a cable provided by PTC to Kurakakaul where they are transmitted. Local programmes take the same route to the transmitter. The studio broadcasts local programmes from 5am to 8am and 5pm to 11 pm and is used for recording during the day. The Kalang FM service also follows the same route.

Currently there is a very temporary studio at the disaster centre in Kokopo which is relaying signals to Navuneram (on the caldera rim between Rabaul and Kokopo). National radio is being transmitted from Navuneram using an FM transmitter/receiver donated by Telikom.

NBC's studio near the Rabaul market has collapsed and the equipment for receiving, transmitting and recording has been lost.

The complex at Kurakakaul includes some radio link elements of the AIDAB funded Bougainville Restoration Programme which were not finished at the time of the eruption. The antenna is lying on the ash covered ground and the mast has a liberal coating of ash. These items need to be cleaned and the project should be finished as soon as possible.

NBC also owns ten houses in Rabaul. Seven houses south of Queen Elizabeth Park are destroyed but three others in the west have only minor damage.

3.6.4. Television

The only non satellite TV service, a commercial channel, was received by a private studio in Rabaul and then rebroadcast from the mast at Navuneram. The studio has been destroyed and the service is not operating.

3.6.5. Newspapers

There is no local newspaper but national newspapers were widely available during the assessment team's visit.

3.7. EDUCATION

Education facilities in the Rabaul area have been badly affected by the eruption. All classes in Gazelle Peninsula schools are suspended during this term, with the exception of Palmalmal High School. Children in Gazelle Schools will not sit for written Grade 6 and grade 10 examinations. Education personnel have been allocated space at the Vunadidir Training Centre. School inspectors, clerical and professional officers are located in class rooms at the Kokopo High School.

3.7.1. Community schools

Grade 1 to 6 education is provided through community schools. Eight community schools with a total enrolment of 3331 students have been severely damaged. The schools damaged are Matapit, Street Martins, Torchbearer, Kamarere, Nodup, Malaytown, Malaguna and St Michaels. Virtually all teaching materials and equipment in these schools were also destroyed during the eruption. Teaching materials worth K158,000 which had only recently been obtained for classes in 1995 were also destroyed. Generally a community school comprised one classroom per 35 students, an administration building and a small library.

3.7.2. Provincial high schools

Year 7 to 10 education is provided through provincial high schools. Provincial high schools are administered and funded by Provincial Governments.

Three provincial high schools with a total enrolment of 1871 students have been extensively damaged by the eruption and subsequent flooding. The schools affected are St Marys, Rabaul and Boisen.

St Marys is located on the north coast near Vuvu. Nearly all the damage to St Marys was due to flooding and looting as the ash fall in the area was only about 150mm.

Rabaul High School is located in Kombiu Street Rabaul. Most damage was inflicted by ash fall with only minor damage by flooding.

Boisen School is located on the north side of Namanula Hill and once again most damage was caused by ash fall.

Damage at the three provincial high schools is shown in Table 1 below.

3.7.3. International schools

The International Education Agency operates one school offering classes from preschool to Grade 10. It is located on two sites in Central Avenue and Malaguna Street and has a population of 240 students.

Damage to buildings is shown in Table 2 below.

TABLE 1 - DAMAGE TO PROVINCIAL HIGH SCHOOLS

School	Description	Destroyed (No)	Repairable (No)	Undamaged (No)
St Mary's (Vuvu)	General Classroom	4	5	0
	Special Classrooms	0	4	0
	Science Classroom	0	2	0
	Dormitories	0	2	0
	Admin Block	0	0	1
	Kitchen	1	0	0
	Dining Hall	1	0	0
	Ablutions	5	0	0
	Workshop	1	0	0
	Ancillary Buildings	0	7	0
	Staff Accommodation	0	18	0
	Library	0	0	1
Rabaul H S	General Classroom	16	0	0
	Science Classroom	3	0	0
	Admin Block	1	0	0
	Special Classrooms	6	0	0
	Ablutions	1	0	0
	Assembly Hall	1	0	0
	Ancillary Buildings	1	0	0
	Staff Accommodation	10	4	0
	Library	1	0	0
Boison H S	General Classroom	6	10	0
	Science Classroom	0	4	0
	Admin Block		1	
	Special Classrooms	2	2	0
	Ablutions		1	
	Assembly Podium	1		
	Staff Accommodation		12	6
	Library	1		

TABLE 2 - DAMAGE TO RABAUL INTERNATIONAL SCHOOL

Description	Destroyed (No)	Repairable (No)	Undamaged (No)
General Classroom	6	4	
Admin Block	1		
Resource Centre	1		
Ablutions		1	
Assembly Hall	1		
Staff Accommodation	1	5	
Library	1		
Preschool Centre	1		

3.7.4. College of Distance Education

The College of Distance Education has an office in Matupit St, Rabaul which serves the Island Region. The College has approximately 2 500 students enrolled in various courses and a staff of approximately 10. The college's offices were destroyed during the eruption with the loss of all office equipment. The area of the office could not be determined during field trip but is estimated to be about 100 square metres by assuming a floor area of 10 square metres per person.

3.7.5. Rabaul Business College

The school is administered by the national government and located in Malaguna Road. It has approximately 320 students in grades 7 to 10 inclusive.

Damage to buildings is shown in Table 3 below.

TABLE 3 - DAMAGE TO RABAUL BUSINESS COLLEGE

Description	Destroyed (No)	Repairable (No)	Undamaged (No)
General Classroom	6	4	0
Special Classrooms	1	0	0
Dormitories	0	3	0
Admin Block	1	0	0
Kitchen/Mess	0	1	0
Ablutions	0	2	0
General Store	1	0	0
Ancillary Buildings	0	7	0
Staff Accommodation	2	2	0
Shower/Laundry	0	4	0

3.7.6. Rabaul Provincial Public Library

The Public Library was managed by the Provincial Department of Education and is located in Namanula Road. The roof of the library has been damaged by ash and will need to be replaced. The walls, internal columns and partitions appear to be repairable. The library has a floor area of 400 square metres. Approximately 75% of the library's stock of 19,900 books has been damaged by water and will need to be replaced. All video and office equipment has been damaged. Extensive flooding has occurred which may necessitate the replacement of some electrical wiring. All salvaged books have been stored at Ulaveo Plantation.

3.7.7. Tok Ples Skul

The Tok Ples Skul office in Rabaul is damaged beyond repair. The office accommodated five staff and a materials store. Some office material has been salvaged and stored at Malabunga High School. the estimated size of the office is 50 square metres based on a floor of 10 square metres per staff member.

3.7.8. Rabaul University Centre

The University Centre is located in George Brown St. Little damage has occurred to the centre and therefore the institution is not considered further.

3.7.9. Rabaul Girls Vocational School

This institution is located in Sulphur Creek Road. The complex, comprising 6 wooden classrooms and a small office, has been completely destroyed.

3.8. HEALTH

3.8.1. Rabaul Town Clinic

The Rabaul Town Clinic, situated in Malaguna St, was operated by the Provincial Government and provided the following services

- Dental Clinic
- Outpatients - child and adult
- Mother and Child Health
- Nutrition
- Disease Control.

The clinic was closed after the eruption with the functions being relocated to various sites in the Kokopo area. Extensive damage has been inflicted on the clinic's buildings, stores and equipment due to the eruption and subsequent rain. Details of the facilities provided and the extent of damage in Table 4 below.

TABLE 4 - DAMAGE TO RABAUL TOWN CLINIC

Building	Area Sq m	Type of Construction	Equipment	Damage
STD/AIDS Clinic	55	Timber	Office, K10,000 of equipment provided by the EU damaged	Roof damaged, water damage vandalism
Family Planning Malaria Section TB Clinic Non Communicable	100	Block Walls Timber Roof	Office equipment	Roof damaged Water Damage Vandalism
Nutrition	36	Timber	Office equipment, little damage	Roof damaged Water damage
MCH	208	Blockwork Walls, Timber roof, steel joists	Unknown, building intact	Roof damaged Water damage
Haus Win	30	Timber	Nil	Destroyed
Adult Out Patients	208	Blockwork Walls, Timber roof, steel joists	Badly damaged	Roof damaged Water damage
Toilets	30	Blockwork	Nil	Nil
Extension Services	90	Timber pole construction	Office equipment	Roof Damaged Water Damage
Dental Clinic	100	Wooden	Office	Roof Damaged Water Damage
Covered Walkways	40	Steel	Nil	Roof damaged

3.8.2. Nonga Base Hospital

Before the eruption Rabaul was served by the Nonga Base Hospital which also served as a specialist referral hospital for the New Guinea Islands Region. Nonga Base Hospital has suffered little direct damage from the eruption but ash was still falling on 25 October in significant quantities.

There appears to be no structural damage to the to the JICA financed, newly constructed section of the hospital. The crates of medical equipment valued at K1 million supplied by JICA under grant aid were stored inside and found to be in good condition with no signs of water damage or attempted vandalism. The equipment includes X-ray diagnostic systems, an ultra sound scanner, a glucose analyser and a cellulose acetate electrophoresis appliance. The external mounted air conditioning system for the new buildings was in good condition but may need cleaning before being used because of dust contamination. The building may need protection in the future from flooding associated with increased runoff due to ash deposits in the land above the hospital.

The failure of the electricity and water supply associated with the fall of ash led to the closure of the hospital. Once the hospital was closed and the staff evacuated to Kokopo looters caused minor damage to the hospital. Electricity and water has now been restored to the Nonga area but electricity has not been reconnected to the hospital due to the fire hazard associated with a dirty electrical reticulation network. Staff houses at Nonga Base Hospital have been damaged by looters. All patients and staff from Nonga Base Hospital have been transferred to Vunapope Hospital near Kokopo and to Butuwin Health Centre. Butuwin Health Centre now operates as an extension of the Vunapope Hospital and

can accommodate 50 patients. Space for the 50 beds at Butuwin Health Centre was provided by converting the CHW Training School classroom and kitchen into wards. Vunapope Hospital and Butuwin Health centre combined can now accommodate 270 patients.

3.8.3. Rabaul School of Nursing and Nonga Workshop

The Rabaul School of Nursing, adjacent to Nonga Base Hospital has also been closed although no significant damage has occurred to the facilities from the eruption. The Health Workshop at Nonga has not been damaged.

3.8.4. Islands Region Area Medical Store

The Islands Region Area Medical Store, located in Blanche St, which services the New Guinea Islands Region has been closed. All medical supplies for the other provinces will be sent to a destination to be nominated by the PNG Department of Health and supplies for ENB are being stored in the Vunapope Timber Yard. Vaccines requiring cold storage are being stored in a privately owned cool room until the cool room at the Area Medical Stores can be relocated to the Vunapope hospital.

3.8.5. Offices

The following office buildings servicing the health sector in Rabaul have been completely destroyed by the eruption.

- Regional and Provincial Offices
- Provincial Malarial Laboratory
- Provincial Information centre.

The Provincial Department of Health shared office facilities with the New Guinea Islands Region staff of the PNG Department of Health in Matupit St. The building was owned by the provincial government. It was completely destroyed by ash along with all records, computers and office equipment. Five Provincial and ten National officers worked in the building.

The Provincial Health Office has been relocated to the Butuwin Health Centre near Kokopo along with community health, disease control, nutrition, family planning and health education from the Rabaul Clinic.

3.8.6. Kamarere Street Building

The Province operated a Dental Clinic which it intended to convert into a handicapped rehabilitation centre after a new dental clinic building was opened on the Rabaul Town Clinic site. The roof of the 150 sqm building was extensively damaged and water and silt have damaged all the dental equipment intended for use in the new clinic. One wall has also been damaged. The building was on low concrete stumps.

3.9. LAW AND ORDER

The Law and Order sector consists of the Police, Attorney Generals Department, Corrective Institutions Service and Department of Justice. Damage to buildings is shown in Table 5 below.

TABLE 5 - DAMAGE TO LAW AND ORDER SECTOR BUILDINGS

Description	Location	Destroyed (sq m)	Repairable (sq m)	Undamaged (sq m)
Court House	Namanula Rd	90	940	0
Public Solicitors #	Namanula Rd	200	0	0
Prov & Rabaul Police St	Mango Rd	80	790	0
Islands Div Police St	Mango Rd	240	0	0

Note: # The Public Solicitor shares office space in a building with the Post Office and the exact area is difficult to determine because the building is badly damaged.

In addition to the abovementioned buildings, office equipment in these buildings was destroyed. Three police motorbikes were buried by ash and damaged beyond repair. The standby generator was also damaged by ash when the roof of the generator shed building collapsed. Forensic science equipment was also badly damaged during the eruption and will probably require replacement. Other police facilities in ENB, including the Mobile Squad complex at Tomaringa, were not damaged.

The Divisional (the five New Guinea Island Provinces), Provincial and Rabaul policing functions and staff have been relocated to Tomaringa Police Barracks and Kokopo Police Station.

The Police Barracks in Edinburgh Street were completely destroyed. The Barracks comprised

- Single quarters accommodation for 52 people
- Married quarters for 31 families
- Gymnasium
- Kitchen and Mess
- Quartermasters Store
- Dog Unit Facilities.

The Police Force owned 13 houses in Rabaul for senior officer accommodation. Approximately 10 of these houses were destroyed by the eruption.

Staff displaced by the destruction of accommodation have either been repatriated to their home provinces or temporarily rehoused at the Tomaringa Police Barracks.

3.10. GOVERNMENT ADMINISTRATION

3.10.1. Provincial Government

The description and condition of Provincial Government buildings affected by the eruption are provided in the Table 6 below.

TABLE 6 - DAMAGE TO PROVINCIAL GOVERNMENT BUILDINGS

Description	Location	Destroyed (sq m)	Repairable (sg m)	Undamaged (sq m)
Provincial Complex	Kuanua St	84	2000	184
Provincial Assembly Complex	Casaurina Av	350	710	0
Vesters St complex	Vesters St	495	65	
Lands & Forests Complex	Mango St	1070	55	0
Division of Education	Malaguna St	0	400	0

The Kuanua Street complex consists of the following buildings:

- A two storey concrete building with a total floor area of 1590 sq m. The roof of this building has been completely destroyed and water and silt damage is extensive to the interior. The walls and floors are in good condition.

- A two storey wooden building with structural steel frame consisting of external columns. The roof has been destroyed and some structural steel columns are deformed. Silt and water damage affects most of the building.

- Several single storey wooden and blockwork buildings of various ages. Mostly these buildings are damaged beyond repair.

The Casaurina Street complex houses the Provincial Assembly Building and associated offices. It consists of the following buildings:

- Provincial Assembly Building which is a single storey wooden building with metal cladding. The roof and portions of the walls of the building are damaged but it is repairable. The building is air conditioned and has a floor area of about 260 sq m.

- The Print Office is a single storey fibro building which is damaged beyond repair. The printing equipment appears to be damaged beyond repair.

- There are three other single storey office buildings constructed of timber and blockwork. The condition varies with approximately 60% of the buildings being repairable.

The Vesters Street Complex comprises the following buildings.

- Electoral Commission. This building has a damaged roof only. The walls are in good condition. Area 65 Sq m

- Labour Department. This building is a single storey building made of fibro. The building has a badly damaged roof and walls and is beyond repair. Area 65 sq m.

- Department of Agriculture. Similar to the Labour Department building with a floor area of 90 sq m.

- Division of Commerce and Tourism. Similar to the Labour Department building with a floor area of 90 sq m.

- Department of Primary Industry. Similar to the Labour Department building with a floor area of 250 sq m.

The Departments of Lands and Physical Planning and Forests buildings in Mango Street are in the following condition:

- Department of Lands and Physical Planning had three buildings. There are two double storey wooden frame buildings with a total floor space of 770 sq metres which have been completely destroyed. The other building is a single storey wooden frame store room which, although damaged, is repairable.

- The Department of Forests has one double storey wooden building with a floor area of 290 square metres. This building has been destroyed.

The Division of Education buildings in Malaguna Street are single storey wooden frame buildings with fibro walls. All buildings have damaged roofs with some slight damage to the external walls and internal partitions.

3.10.2. National Government

The description and condition of the National Government Buildings in Rabaul which were affected by the eruption are provided in Table 7 below.

TABLE 7 - DAMAGE TO NATIONAL GOVERNMENT BUILDINGS

Description	Location	Destroyed (sq m)	Repairable (sg m)	Undamaged (sq m)
National Disaster and Emergency Service	Gov Hahl Drive		150	
Fire Station	Mango Av	250		
National Housing Commission.	Malaguna Rd		120	
Provincial HQ Dept of Works	Malaguna Rd	2 962	230	120
Vehicle Workshop Dept of Works	Malaguna St	1 363	56	405
Dept of Transport	Cleland Dr			100%
DOW supply office	Malaguna St	1 240	154	1500
Vulcanological Obs	Tunnel Hill			100%

The National Disaster and Emergency Service Office is a high set house with an enclosed space below. Considerable damage has occurred to the roof and minor damage to one wall.

The Fire Station has been destroyed with extensive damage to the roof and walls. The concrete water tank adjacent to the station is in good condition. A married residence and single quarters to the rear of the station have also been destroyed.

The office of the National Housing Commission has damage to the roof only with the walls in reasonable condition.

The DOW supply office buildings that are not damaged are currently vacant. They are therefore available for use by others. The sheds could easily be converted into offices by constructing partitions and providing electric power outlets.

The Provincial Headquarters of the Department of Works complex in Malaguna Street comprises the buildings listed in Table 8 below, which also shows their condition.

TABLE 8 - DAMAGE TO DOW PROVINCIAL HEADQUARTERS BUILDINGS

Description	Type	Condition	Area sq m
Main Office	Wooden and Fibro	Destroyed	450
Regional Office	Wooden and Fibro	Roof and walls damaged. Repairable	230
General stores	Steel frame, metal cladding	Destroyed	300
Static plant Workshop	Steel frame, metal cladding	Destroyed	160
Electrical Store	Steel frame, metal cladding	Destroyed	75
Carpentry Store	Wooden frame, metal cladding	Destroyed	360
Plumber Store	Wooden frame, metal cladding	Destroyed	50
Joiner's Office	Wooden frame, metal cladding	Destroyed	25
Joinery Shop	Wooden frame, metal cladding	Destroyed	160
Machine Shop	Steel Frame, metal cladding	Destroyed	810
Electrical Workshop	Wooden frame, metal cladding	Destroyed	160
Paint Shop	Wooden frame, metal cladding	No damage	120
Car garage	Steel frame, metal cladding	destroyed	250
Operations Office	Wooden frame, metal cladding	destroyed	72

The condition of the Department of Works Vehicle Workshop buildings in Malaguna Street is shown in Table 9 below.

TABLE 9 - DAMAGE TO DOW MOTOR VEHICLE WORKSHOPS

Description	Type	Condition	Area sq m
Main Office	Wooden and Fibro	Roof damaged	60
Plant Workshop	Steel frame ,metal cladding	Roof and walls damaged. Destroyed	658
Workshop	Steel frame ,metal cladding	Destroyed	120
Machine shop	Steel frame ,metal cladding	Destroyed	240
Boat Store	Steel frame ,metal cladding	Destroyed	153
Garage	Wooden frame, metal cladding	Destroyed	360

Description	Type	Condition	Area sq m
Plumber Store	Wooden frame, metal cladding	Roof damaged	54
Joiner's Office	Wooden frame, metal cladding	Destroyed	25
Workshop	Steel Frame, metal cladding	Undamaged	405

Equipment in the machine shop was partially damaged when the building was destroyed

3.11. COMMERCIAL PREMISES

The team did not do a detailed assessment of damage to commercial and industrial premises. Its members did note however that there was catastrophic damage to many buildings. In Malay Town the trade stores and warehouses are devastated. In Mango Ave the commercial and retail premises are extensively damaged. At the western end of Malaguna Road the ash fall was lighter and the industrial and light industrial buildings there are less affected but even there most larger buildings have at least some sections of collapsed roof. A notable exception is the Roman Catholic church in Malaguna Road. The reason is obvious. It has a much steeper roof and most ash slid off it.

3.12. HOUSING

As with commercial premises the team did not do a detailed damage assessment of housing. However, in the course of inspections of public service properties its members inspected many houses owned by government agencies, and observed many others.

It is safe to say that most houses have been damaged to some extent. A high proportion of those which have not collapsed will need to be re-roofed. Detailed inspections almost invariably reveal serious structural damage to their roofs. The corrosive nature of the ash will probably mean that even those with light structural damage will not last long with their current roofs.

As with commercial buildings it was observed that generally, the steeper the roof, the more likely the house was to survive. A poignant example of this is a small, covered outdoor eating area in a front garden near the Police barracks in one of the worst hit areas. The steep conical roof is constructed of bamboo and thatch but it is the only building in sight which is still standing.

Gutters are another problem. Even on some steeper roofs which allowed the ash to slide down, the gutters formed dams and consequent ash build up. Houses without gutters seemed to fare better than those with them. Gutters are essential to catch drinking water but alternative methods of attachment and location should be investigated.

Corrosion is looming as an enormous problem for all structures, including houses. It is becoming apparent that compounds formed by sulphates and chlorides in the ash are highly corrosive and that the corrosion will be very difficult to arrest. Most houses have metal roofs, gutters and rainwater tanks. It is likely that these metal parts now have very limited lives unless they are cleaned soon and thoroughly. It may already be too late for many buildings. Drinking water from roof runoff will need to be carefully monitored to ensure that it is safe to drink.

4. PLANNING ISSUES

4.1. BACKGROUND

4.1.1. Rabaul before the disaster

To those who know and love the Pacific Islands Rabaul has always been one of its loveliest towns. Its short history starts in the time of Queen Emma. Through the German, Japanese and Australian administrations of the first 75 years of this century and in the last 19 years of independent government Rabaul has been a lively, prosperous and colourful town.

Rabaul is located on the north-eastern tip of the island of New Britian in a fine harbour which is sheltered from the prevailing SE Trade and NW Monsoon winds. It is recognised, along with Lae, Mt Hagen and Port Moresby, as one of the four regional centres in Papua New Guinea's urban hierarchy. It functions both as the seat of government for East New Britian Province and as a shipping, communications and service centre for the 5 provinces in the Islands Region. Rabaul port is the third busiest in the country. In its inbound mode it functions as a transhipment centre for the distribution of consumer goods, equipment, fuel, fertiliser and other inputs to the many small coastal towns in the region. In its outbound mode it is an international port for the export of copra and cocoa and other tropical tree crops from the other provinces.

With a population of 17 044 in 1990 Rabaul is the 7th largest centre in PNG. With a relatively low growth rate through the 80's and rapid growth rates in mainland and highland centres Rabaul has been declining in relative importance. A growth rate of 3.1% pa is taken as the low level for projection of growth for PNG's urban centres generally - the rate for Rabaul is taken as 2.6% pa.

The town occupies a narrow strip within the caldera rim and Simpson Harbour. The caldera rim approaches to within two kilometres of the bay at the site of the port. The town is laid out on a clear rectangular grid pattern with the principal roads being.

- Malaguna Road runs east/west across the northern part of town. It connects in the west first via the Tunnel Hill road to north coast areas and then a little further west via the Burma road to Kerevat and other inland areas of the Gazelle Peninsula. The Kokopo Road runs along the western shores of Simpson Harbour skirting the base of the caldera rim and then around Blanche Bay to Kokopo.

- Mango Avenue runs south from Malaguna road to define the eastern part of the town. Its southern extension runs through Malay town to the airport which is located near Matupit Island - a short distance away from the Tavurvur volcano.

- Namanula Road climbs over the caldera rim to the east to provide access to villages such as Nodup.

A clear pattern of activities is found in the town. Port activities, warehousing and distribution and some manufacturing are located between the port and Malaguna Road in the northern part of town. Government offices, retailing and other commercial activities are located to the north east along the two main roads and particularly around their intersection. The thriving town market and a number of community facilities are located in this area. Smaller commercial activities and retailing with some professional services are found along Mango Road towards the airport and in the Malay town area. Housing is provided in the form of compounds for employees of the larger employers, in squatter settlements on the edge of town and in low and high covenant housing areas for government employees and private sector residents. High covenant housing is found to the north of Malaguna Road and lower cost housing is found in the Malay town area and elsewhere throughout town.

Land availability and tenure have played a very significant part in shaping Rabaul's physical structure and composition. Suitable extension areas for the town have been fully built out for some considerable time now and there is very little opportunity for infill. Some of the effects of this land shortage have been:

- a home/work pattern in which as many as 60% of the town's workforce commute from village areas in the Gazelle Peninsula. Commuters seem to be about equally divided between the north coast, the central Gazelle Peninsula and the Kokopo areas. Commuting trips of 20 km and 30 minutes are probably about average.

- the location of a number of major institutions such as the Nonga Base Hospital, the police college and the correctional institution beyond the caldera. These institutions have not been clustered in any particular area or existing centre - principally because of difficulties in securing the transfer of sufficiently large parcels from customary to torrens title.

- difficulties experienced by existing enterprises wishing to expand and new enterprises with large land requirements.

Rabaul consistently performs better than the average for urban centres in PNG on the common development indicators. For example in its Urban Sector Profile for PNG the Asian Development Bank reports that by comparison with the average for all the main urban centres in PNG Rabaul has:

- less low cost and "makeshift" housing and more high cost housing
- a high proportion of its work force in private sector employment
- lower infant mortality, percentages of malnourished children and people with no schooling
- and higher life expectancy, per capita income and population/hospital bed ratios.

While the fertility of the Gazelle Peninsula soils, the productivity of the small holder and plantation sectors and the industry and high level of education of the Tolai people are clearly important factors there is also a degree of distortion in the figures arising from the physical constraints imposed on growth of the Rabaul urban area by the caldera rim. For a generation now there have been no significant areas of land available for urban expansion. Figures for the township of Rabaul do not therefore reflect the very large proportion of Rabaul's workforce (possibly as high as 60%) which lives outside the town boundaries.

In very broad terms the social composition of the town can be summarised as follows:

- officials, mostly Tolais working for the Provincial government and living in town in low and high cost housing provided by the government

- officials including Tolais and a significant number from other provinces working for the National Government and living in town in low and high cost government housing.

- owners, senior staff and "white collar" workers in the private sector living in town in low and high cost accommodation provided or subsidised by the enterprise

- employees for both the public and private sectors living in villages in the Gazelle Peninsula and commuting daily to work

- employees mainly "blue collar" from other provinces living in "informal" housing in squatter settlements in town.

In summary then Rabaul is a town which has exploited and developed the advantages of a central location, a rich hinterland and fine harbour to become a very attractive regional centre. It is located within an active caldera complex in a zone of very high volcanic hazard. The physical constraints of the caldera rim have allowed the town to develop and maintain a truncated social structure along with a high physical amenity. There has been a failure in public administration to lead and direct the natural overspill of public sector activities from the town into the Gazelle Peninsula to form an overall settlement pattern which strengthens Rabaul's regional service centre role.

Risk minimisation considerations point to reduction of Rabaul's population; relocation of urban functions from Rabaul creates the opportunity to remedy some of the long standing structural defects in the sub region and to put the regional service centre role on a firmer footing for the future.

4.1.2. Damage patterns

Section 3 of this report provides a detailed description of damage to structure and services caused by the eruption.

Tables 10 and 11 below summarise this information according to service sector (public sector serving the whole islands region, private sector with medium scale establishment and therefore likely to focus on the Province of ENB and etc) and on location within the township. Sector 1 is in the northern part of town, Sector 2 is in the north-east and Sector 3 is in the east.

TABLE 10 - DAMAGE PATTERN - Buildings

Sector/Orientation	Location-Sectors	Damage
Public - regional	2 and 3	Medium - heavy
- provincial	2 and 3	Medium - heavy
Private - large	1	light
- medium/small	2 and 3	heavy
Housing - high covenant	1 - part 3	light
- low covenant	3 - part 1	heavy
- informal	fringe	heavy

TABLE 11 - DAMAGE - Services

Service	Coverage % of town	Plant	Network Damage	Location Sector
ROADS	full	-	surface OK continuing clean-up	heaviest in 3 - mud flows?
ELECT	full	generators OK	Street poles OK trans system? wires? house/bus connections	same in all sectors
WATER	full	pumps OK	reticulation system OK	all OK
PHONE	full	exchange ruined	underground cables not checked	no reports
SEWERAGE	commercial area only	pump OK	system needs cleaning out	only commercial sector -2

4.2. ISSUES

4.2.1. Objectives

The comments most frequently heard around the Disaster Centre were relief that no more than 5 lives had been lost and the port was reopening and opinion that the best thing to do now is to get Rabaul going again.

The concerns behind these comments are to do with concern about risk minimisation, cost minimisation and a desire to maintain ENB as a regional service centre for the Eastern Islands region.

Broad goals for framing responses to the disaster can therefore be defined as follows:

- to minimise future risk to lives and property
- to minimise further disruption to individuals and groups in Rabaul and the Gazelle peninsula
- to maintain ENB's role as provider of higher level services to the Islands region.

The core issues are (i) should Rabaul be fully re established? (ii) if some reduction in risk is to be achieved through population reduction which urban functions should be relocated and where should they be located? Table 12 summarises the above points.

TABLE 12 - OBJECTIVES

Comments	Concerns	Goals
Thank goodness so few lives lost	Risk minimisation	Minimise future risk to lives and property in the Gazelle peninsula
Thank goodness port is reopening	ENB as regional centre	maintain regional and provincial centre function
The most sensible thing to do now is to get Rabaul going	cost minimisation	Minimise further disruption to community and property

4.2.2. Responses

The two broad responses to the eruption are to rebuild or to relocate. The rebuild response places a very high priority on minimising cost by making the best of the structures and services that are in the town. The argument is that this is the cheapest and also in the end it will be the most effective means of re-establishing Rabaul as a regional service centre.

This response attaches a relatively low priority to risk reduction.

The relocation response reverses the priorities, the argument is that you should not play around with human lives: this time only a few lives were lost but the next time could see a major loss of life and distribution to property over gain. There is also the argument that short term donor assistance and longer term investment support from financiers will be much more readily available where there is a strong commitment to substantial risk reduction. In effect the way to re establish the regional centre functions is to reduce risk.

These points are summarised in Table 13.

TABLE 13- RESPONSES

Concerns	Rebuild Response	Relocate Response
Risk minimisation	Low priority	High priority
Maintain regional centre role	Rabaul as the hub	A port town and an airport town
Cost minimisation	High priority	Low priority
Rationale	. key services OK . time is critical . least cost solution is essential . the port is the critical issue-freight movement	. not just cost- also availability of resources . unless risk is reduced short term assistance and long term investment will be inadequate . growth sector is people/airport oriented

4.2.3. Stakeholders

The immediate effects and the longer term consequences (the costs) of the eruption will be different for different groups and sectors. There are at least two elements to cost: loss caused at the time of the eruption and difficulties experienced in re establishment. Some groups will have great difficulty in re-establishing a new livelihood because their land has been ruined or because their suppliers and/or customers are scattered and out of business. These considerations will influence how they react to any relocation program.

a. **Fringe villages:**
Undoubtedly the group most severely effected are the communities living in the villages which were completely destroyed by ash fall. These communities lost their homes and their livelihoods and will have to resettle elsewhere. They will have to rely on emergency assistance and relief to get re established.

b. **Small businesses:**
These have suffered very heavy damage both to buildings and to accommodation. In addition to high costs for rebuilding they face low cash flow and high uncertainty for a considerable period while relocation issues are resolved and communities rebuild. They are more dependent on the local and Provincial economy than larger enterprises which are processing produce from the hinterland or distributing goods and services to customers in other provinces.

c. **'Blue collar' town residents:**
These have lost both employment and accommodation. In theory those from other provinces have more mobility since they have some claim on their home community. In practice they are likely to be destitute, without the means to return to their home areas and with few prospects there if they do so. Any tendency to adopt exclusionary urban development measures or to over-design building and other codes will adversely effect the ability of this group to relocate and re-establish.

d. **'White collar' town residents:**
As a generalisation this group were living in rental accommodation that was subsidised by their employers. They have therefore lost their possessions and personal effects but mostly did not lose their homes. Many of those working for small business will lose their jobs but a significant proportion who are employed by larger enterprises or government agencies will have continuity of employment. Where they move with their employer they should be able to relocate much more easily than others moving on their own account.

e. **Gazelle Peninsula residents working in Rabaul:**
With the exception of the villages mentioned in a). above this group has suffered little or no damage to housing. Many will be out of work at least temporarily and if significant levels of relocation of activities from Rabaul occurs there will be more or less significant changes to job opportunities and commuting patterns.

f. **Communities in the Gazelle Peninsula generally:**
Relocation of provincial government activities will improve access to these services for some communities but may reduce accessibility for others. Relocation to Kokopo is likely to result in an overall improvement in accessibility for communities in the Gazelle Peninsula.

g. **Business, consumers and other in the rest of the Islands Region:**

These groups should suffer relatively little disruption. Operations at Rabaul port are returning to normal; the larger enterprises that handle the distribution and trading activities on which they rely have suffered relatively little damage and Tokua airport is functioning even if full commercial services may not be available for some time.

h. **Larger business:**
Larger businesses were clustered in the western end of town - an area which suffered relatively light damage. In so far as these activities are port related they will experience relatively little difficulty in reestablishing. Their suppliers - whether in the Gazelle Peninsula or Lae - and their customers - who in large part are in other provinces or overseas - have not been effected by the eruption. They can therefore establish a positive cash flow as soon as they can open their doors for business. Because they are the least likely candidates for relation they will be spared much of the uncertainty that will preoccupy small business until the relocation issued is resolved.

i. **Governments:**
The provincial government faces a large re establishment cost for its facilities. It is a prime candidate for relocation. The provincial government will have to get the Gazelle Peninsula operating again at the same time as it continues to administer the rest of ENB. It will have to coordinate the on-the-ground delivery of external assistance while rebuilding its own administrative capability.

The national government is also a prime candidate for relocation. The national government will need to find resources to assist ENB to get operating again within a very tight financial environment. It could greatly assist the relocation activities of the provincial government by committing itself at an early stage to a relocation program. This would do much to overcome the uncertainty facing the small business sector.

Both governments have a clear responsibility to ensure that the influence of articulate sectional interests do not unduly influence attempts to find an appropriate balance between short term cost minimisation and longer term risk minimisation.

The issues considered above are summarised in Table 14.

TABLE 14 - STAKEHOLDERS - Losses and re-establishment

Group	Loss Suffered	Ability to Establish Activities	Responsible Asst. others	"Costs" - relative
Fringe villages	heavy	dependent on assistance	informal	high
Commerce-small/med business	heavy	cash flow disrupted for indefinite period. Uncertainty about location	some staff housing	high
Industry - larger estab.	light	access to cash flow as soon as doors open-most suppliers and customers not affected	staff housing	low
Gazelle Peninsula commuters	employment	village support and good work prospects in medium term	informal	low
Town residents -	personal possessions	little equity in housing - some job security and continuity of employment	informal	low
Squatters	heavy	expected to return to home province - no re-establishment assistance	informal	high
NGO's	heavy	severe dislocation of community networks etc	high	high
Provincial government	medium-heavy	tight budgetary situation - dislocated administration	major	very high
National government	medium-heavy	tight budgetary situation	major	very high

4.2.4. Hazards and risks

The Rabaul area is one of the most volcanically active areas in the world. It lies at the eastern end of the Bismarck Volcanic Arc which extends for some 1 100 kms along the north coast of PNG and through New Britain to Rabaul. Among the more notable of the recently active volcanoes in this arc are Manam, Karkar, Uluwan and Long Island.

The very high level of volcanic hazard in the Rabaul area has been underscored in a number of recent studies.

- The Rabaul volcano was ranked as having the highest hazard level out of 14 active and 20 dormant volcanoes in PNG.

- A nation wide study of volcanic calderas ranked the Rabaul caldera in the top 3 in the world along with calderas in Italy and the USA.

The three eruptions which have occurred in historic times have allowed a small but growing body of information to be assembled about patterns of seismicity, warning signs or precursors and the hazards and risks associated with medium sized eruptions.

In overall terms the factors which are most important to the mapping of hazards are the strength of an eruption and its location. A further critical factor is wind pattern. Figure 6 represents, in highly summarised form, hazard mapping for ash falls and pyroclastic surveys and flows for the Rabaul area. It can be seen from this figure that:

- Rabaul falls within the zone with the highest level of hazard for flowage effects including pyroclastic flows surges and mud flows. It also falls wholly within the zone with the highest level of hazard for ash falls (windblown tephra).

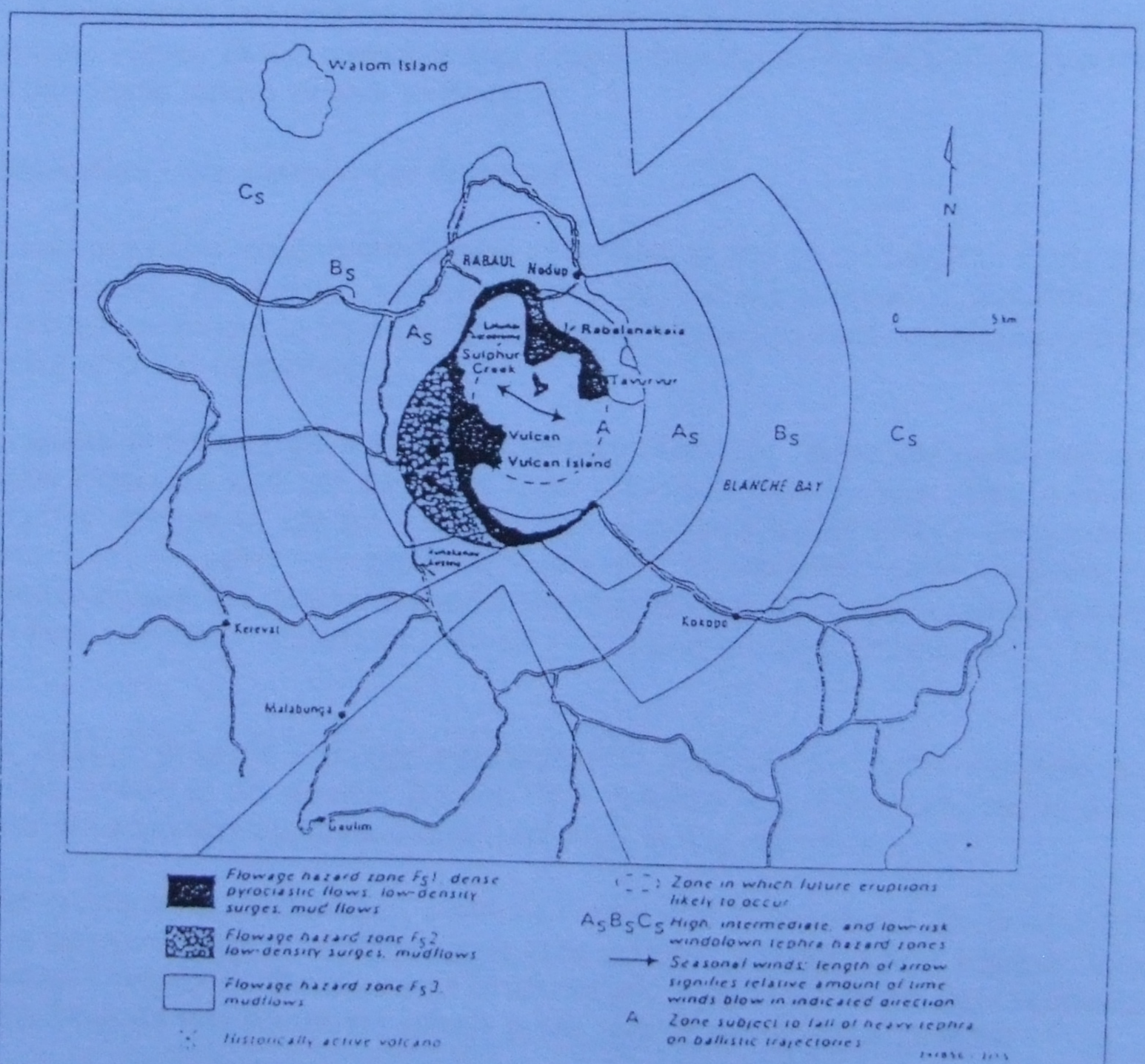
- both Kokopo and Kerevat fall outside the lowest zoning for flowage hazard

- Kokopo falls in the intermediate zone for level of ash fall hazard while Kerevat lies in the low risk zone for ash fall hazard.

Hazard mapping is concerned with plotting the likely extent and intensity of each of the process which go to make up an eruption. Risk analysis is concerned with the destructive impacts which volcanic eruptions may have on land and property. In the next section we look at alternative strategies for Rabaul township with a view to finding a better balance between exposure to risk from eruptions and the other social and economic values and concern of the community in Rabaul and the Gazelle Peninsula.

The issues considered above are summarised in Figure 5 and set out in more detail in Appendix 2.

FIGURE 5 - HAZARD ZONES FOR SMALL AND MODERATE ERUPTIONS AT RABAUL



Hazard zones for small–moderate eruptions at Rabaul

Qualifications: not for major eruptions, only for Tavurvur and Vulcan and only for ash falls and pyroclastic flows/surges

References:
1. Rabaul Caldera, PNG: volcanic hazards, surveillance, and eruption contingency planning, McKee C O et al, Journal of Vulcanology and Geothermal research, 23 (1985) 195-237
2. The impact of volcanic hazards at Rabaul PNG, Blong R and Aislabie C, Institute of National Affairs Discussion Paper No 33, Port Moresby, April 1988.
3. Volcano town: the 1937 - 43 Rabaul eruptions, Johnson R W and Threfall N A, Robert Brown and Associates, Buranda, Australia, 1985.

4.2.5. East New Britian or another province

The 1984 Eruption Urban Planning Study notes Kimbe and Kavieng as possible alternatives to Rabaul in the event of a catastrophic eruption which would destroy Rabaul. It then concentrates on strategies for responding to a medium scale eruption requiring relocation within the Gazelle Peninsula.

In geographic terms ENB and in particular Rabaul Harbour is and will remain the most central location for servicing the islands region. In economic terms the situations are perhaps not so clear cut. Stronger prices for cocoa and copra in recent years have strengthened Rabaul's role as has the situation in Bougainville. But Lae continues to strengthen its position as an industrial and regional service centre. The trend in communications technology and transport infrastructure is to build more direct links between first order centres and outlying areas. For example Kavieng has upgraded its airport to take direct international flights. In this context it appears now that Rabaul might lose the lucrative support role for the Lihir Island mining project to Kavieng.

4.2.6. Relocation - concentration or dispersal

The debate about centralisation/decentralisation of settlement will go on forever. If the critical issue in ENB is to maintain the regional service function then concentration of relocated activities is necessary. If the critical issue is to improve the delivery of services to local communities then dispersal of local servicing activities might help.

There are attractions in the concept of a flat urban centres hierarchy - more small and medium centres - for the Gazelle Peninsula with any functions to be relocated from Rabaul being spread among a number of centres throughout the sub region. Such a pattern would reduce the exposure of the settlement pattern to any one volcanic event - ie reduce risk. By comparison with the heavy commuting patterns needed to support pre disaster Rabaul a dispersed settlement pattern in which urban functions are located in these commuter 'dormitories' should bring significant benefits in terms of reduced travel time and cost.

Certainly the disaster presents a unique opportunity to improve the highly distorted home/work relationship that applied in pre disaster Rabaul. The question is at what scale this is done and the extent to which this consideration should dominate other policy objectives.

The first point is that some clustering of activities is essential if reasonable levels of efficiency and effectiveness in the provision of urban services are to be achieve. Secondly urban activities are mutually supportive: isolated activities will not be able to attract and support the small scale retailing, services and community facilities that contribute greatly to the success of any urban activity.

The examples of the Kerevat Correctional Institute and the Vunadadir Administrative College do not disprove these arguments. Both of these developments involved single large public sector in situations and activities with little need for interaction with other urban activities. And while on paper they present large employment opportunities for local residents in fact staff with the skills and/or the interest for such employment will be drawn from a wide area. This will diminish over time only where there is an active housing market and a population which accepts high residential mobility. This does not

appear to be at the case in ENB.

A degree of concentration or clustering of any functions relocated from Rabaul is therefore highly desirable. This argument is reinforced by the objective of maintaining ENB's role as the base for higher order services for the Islands Region. Dispersal of the urban activities made footloose by the disaster will greatly reduce the Province's chances of establishing a centre with the range and depth of functions to be a credible and effective regional centre.

The 1984 Eruption Study strongly recommended that any relocation activities be concentrated and not dispersed.

The issues discussed above are summarised in Table 15.

TABLE 15 - FORM OF RELOCATION - CONCENTRATION OR DISPERSAL

Form	Activity Level range	depth	Infra Costs	Level of Service
Concentrated	wide	many	lower	high
Dispersed	narrow	few	higher	low

4.3. LOCATION OF AIRPORT AND SEAPORT

Rabaul's origins are as a seaport. Rabaul Harbour is sheltered from the prevailing South East Trades (May to November) and from the North West Monsoons (December to April). It is a deep water international port with wharves for 3 ships at a time and established port facilities. Warehousing capacity is adjacent to the port area and there are a number of manufacturing and processing establishments (bottling, sawmill, paint, copra and cocoa processing) in the immediate port area. Alternative port sites in the province do not enjoy anything like the shelter and depth of water at Rabaul Harbour.

The wharves, shore based facilities and associated enterprises suffered very little damage from the eruption. Marine surveyors cleared the harbour for shipping on the 25 October and cargo was discharged the next day. Stevedores for port operations have traditionally come from villages outside the town so that re establishing port operations is not dependent on re occupation of housing in the town area.

The port of Rabaul fulfils an important function for the whole of the islands region. There is no suitable alternative site. In any programme of risk minimisation through relocation of functions the port function should be the last to be considered.

With improvements in aircraft, changes in the way in which business is done by the private sector and government, and with changes in personal and tourist travel patterns, air transport is now at least as important as sea transport in serving the islands region.

Rabaul's Lakunai airport is located mid-way between town and Tavurvur volcano. It has only been able to operate F28 aircraft on the basis of dispensations from civil aviation regulations for clearances. Night flying operations have not been possible. It experienced heavy ash falls during the eruption. Ground facilities were destroyed. The Department of Civil Aviation has not made a final decision on the future of Lakunai airport, but it is however considered unlikely that it will agree to re establish it as Rabaul's airport.

Tokua airport is located some 15 km to the east of Kokopo and some 45 km from Rabaul. F28 aircraft can operate from Tokua but its coral surface is currently being improved for continuous commercial operations. There are no ground facilities at Tokua. Work has commenced on upgrading the road connection to Kokopo.

The airport was conceived in part as an alternative to Rabaul and partly as a possible international airport which would allow for direct international tourist flights. JICA has made a study for ultimately upgrading to 747 capability. Land acquired for airport development is surplus to foreseeable airport requirements and is being made available for resettlement of villages totally destroyed by the eruptions.

No technical difficulties are foreseen in upgrading Tokua airport to serve the region. No alternative location has been identified in a more central location for the Gazelle Peninsula. Any such location would raise almost insurmountable land acquisition difficulties, would mean writing off the Tokua development and such an airport would be more likely to be subject to night flying and other restrictions than the Tokua site which is sited at the end of Cape Gazelle.

While third level airline operators would find advantage in a two airport system with Lakunai remaining open for charter and other short haul activities the operation of two competing commercial facilities some minutes flying time apart could not be justified on operational or efficiency grounds.

In conclusion then the port function for ENB and the Islands Region should continue to operate from Rabaul harbour under all but the most stringent risk minimisation strategies. Lakunai airport is likely to remain closed. Tokua airport is capable of landing F28's now and could be upgraded to unrestricted regional airport capability (including ground facilities) within a short period of time.

4.3.1. Scope of relocation task

In considering the relocation task the villagers immediately outside the boundaries of the Rabaul township should be treated as residents of the town and included in relocation planning. They are functionally part of the town and they are subject to the same hazard levels as the town residents.

As indicated above it is this group which has probably suffered the greatest loss and face the greatest level of uncertainty for the future. Every care should be taken to ensure that further trauma is kept to the absolute minimum. Proposals for temporary resettlement of these groups should be critically assessed. It may be better to persist for a little longer with care centre arrangements and concentrate significant resources on establishing a basis for a long term solution.

The proposal to relocate 6-8 000 persons from care centres to plantation lands adjacent to Tokua airport is superficially attractive but raises a number of serious questions. The numbers involved constitute a town : even on a temporary basis significant resources, both financial and managerial, will have to be devoted to provision of services and community organisation since there is nothing there now. If the settlement is in fact only temporary then the resources expended on its establishment will be written off when the move to a final location is made. If no follow-up final resettlement programme eventuates then a very substantial community will be left with an inadequate land base for supporting itself through rural production and a very slim chance of generating alternative economic activities sufficient to sustain a viable community of 6-8 000.

A resettlement strategy should be agreed. Eligibility should be limited strictly to households which have suffered total loss of home and livelihood. Settlements should be conceived and organised as permanent sites. So far as possible a range of settlement types should be provided including at least the following.

- Rural settlement
  Small/medium settlements with sufficient land to generate a substantial proportion of household income. These could be provided at some distance from major urban centres - presumably on land already in public ownership. The economic cost of the land should ultimately be recovered but with a grace period to allow families to re establish themselves economically and socially.

- Urban settlement
  Provision should be made in Kokopo (and other centres where possible) for significant areas of low cost housing. The majority of the population to be resettled are likely to want to settle in urban areas. This will minimise land problems associated with acquisition of larger tracts of land for rural settlement.

- Individual settlement
  A modest cash or kind ex gratia payment should be made to eligible householders who prefer to make their own arrangements. This may appear to be overgenerous but is likely to be very cost effective. People able to make their own arrangements are likely to find better solutions quicker than those making use of slow moving programmes. Any such payment should be put on a very clear 'once and for all' basis.

4.3.2. Location

It has not been possible within the time or resource constraints of this mission to undertake any independent assessment of alternatives for the relocation of Rabaul urban functions. The following is a summary of the key points from the brief 1984 Rabaul Volcanic Eruption Study referred to above.

Six sites were considered. An area of 750 ha was considered necessary to accommodate Rabaul's then existing activities and to allow for reasonable future expansion. The selection criteria gave priority to land availability and suitability; existing infrastructure and facilities; road access generally and access to air and sea ports.

Bitapaka and Wharangoi - small inland sites to the south east and south - were eliminated because of small sites (less than 100 ha), minimal/no existing infrastructure, poor access for the population of the north-eastern parts of the Peninsula and long travel times to port and airports at different locations.

Tokua to the east of Kokopo and Vunakanau closer in and to the south of Rabaul had adequate land but were quickly eliminated. Tokua was too far from Rabaul and the north east portion of the Peninsula generally and Vunakanau, which lies 7 km south west of Vulcan, was considered to be an unacceptably risky site.

Kerevat with a possible sea port site at Atiliklikan Bay relying on Tokua or Rabaul for an airport and Kokopo with an emergency port at Kabakaul Bay and an airport at Tokua were the short-listed sites. Some 1 500 ha were considered to be available at both sites. Kokopo was considered preferable to Kerevat on general accessibility and existing infrastructure grounds. An additional consideration was that development at Kerevat would disrupt the long established research programmes of the Lowlands Agricultural Research Station.

The study concluded that:

> "Although more detailed investigation will be needed into such factors as the influence of volcanic activity, the availability of a supply of water, and soil conditions, there is little doubt that Kokopo/Vunapope.. is the preferred location given the information available at present".

and went on to recommend among other things that:

> "Detailed planning should start on the Kokopo/Vunapope area to firmly establish its suitability for urban development. Planning should be directed initially towards providing development land free from the threat of volcanic activity. However there is a need to ensure that possible future development of a town of perhaps 30 000 should not be prejudiced by short term expediency. This could be achieved by preparation of a broad overall master plan".

Reference: Rabaul Volcanic Eruption : preliminary urban planning study, Department of Physical Planning and Environment, Boroko, April, 1984.

The conclusions of the 1984 study would appear to remain valid. (Consultants were appointed to prepare a Kokopo Urban Development Plan on or about the 24 October 1994).

The broad criteria for selection of a site for relocated functions from Rabaul appear to be:

- land availability and suitability
- existing services and infrastructure
- risk minimisation - on the basis of the zones in Figure 6 risk is reduced with movement in a south-westerly direction from Rabaul
- access to region : seaport - remains at Rabaul, airport 'moves' to Tokua. Therefore access to the region is improved with movement in an easterly direction
- access to province - given the distribution of population access is improved with movement in a southerly direction.

Whilst Kokopo has been announced as the preferred location there have been recent reports suggesting that provincial-level activities might be located at Vunadadir. By comparison with Kokopo this location appears to trade airport access against seaport access. On a superficial analysis it is likely to be significantly superior to Kokopo on intra provincial access and slightly superior in terms of risk reduction from ash fall. Vunadadir is clearly inferior to Kokopo in terms of existing infrastructure and facilities and is almost certainly inferior in terms of land availability and suitability.

Kokopo can be adopted with confidence as a suitable alternative for the relocation of functions from Rabaul. Detailed analysis could be undertaken to confirm this and it is possible that a marginally superior site might be located. In all the circumstances it is considered that such analysis is unwarranted and that the Kokopo site should be confirmed and the recently commissioned planning study for Kokopo should proceed as a matter of urgency.

Tables 16 and 17 summarise issues in relation to location.

TABLE 16 - EVALUATION OF ALTERNATIVE SITES - 1984 ERUPTION PLANNING STUDY

Site	Land Area Etc	Existing Infrastructure	Access	Conclusions
Bitapaka	70 ha suitable expansion area not available	none	not very central, relatively close to Tokua, long way from sea port	eliminated
Warangoi	50 ha	minor	remote	eliminated
Tokua	800 ha some not suitable parcels separated	none	12 km further away from Rabaul than Kokopo	eliminated
Kerevat	1 500 ha	conflict with existing institutionaluses	24 km to Rabaul and 60 to Tokua	eliminated
Vunakanua		some institutional developmentin area old airstrip	central location in Gazelle Peninsula	eliminated because too close to Vulcan-7 km to NE
Kokopo/ Vunapope	1 500 including existing town-ship and plantation land	established town with population of 2 000+ and extensive mission facilities	close to Tokua, good road but some distance to Rabaul and to the east of Gazelle Peninsula concentrations	Of 2 possible sites of Tokua and Kokopo the latter must be referred because of better base of existing services and infrastructure

TABLE 17 - ACCESS AND HAZARD ZONING - FOUR CENTRES

Location	Hazard Zone	Rabaul Port Access	Tokua Airport Access	Access to Prov Centre 1-5, 5=high
Rabaul	1	0	39	3
Kokopo	2	27	12	4
Vunadadir	3	about 15	about 20	5
Kerevat	3	24	60	2

4.3.3. Levels of relocation

This section suggests principles to be used in framing relocation policy and identifies a relocation strategy consistent with those principles.

It is clearly highly desirable that everything be done to minimise the risks arising from future volcanic eruptions. An obvious way to do this is to minimise levels of population and property development in areas of high hazard. The township of Rabaul is sited in an area of very high hazard. While Kokopo is also subject to hazard from eruptions, risks from ash fall for medium eruptions at Tavurvur and Vulcan are significantly lower than for Rabaul.

Risk minimisation comes at a cost. There are trade-offs between levels of risk to be attained and the measures that have to be taken to achieve those levels.

It is suggested that the operating principle on which planning for the future of the area should be based is that risk should be minimised to the maximum extent possible consistent with continued operation of such functions as are critical to the stability and growth of the regional economy and which are dependent on location in close proximity to the port in Rabaul Harbour. The extent to which risk minimisation is pursued should not be significantly constrained by consideration of the short term costs of re-establishing Rabaul's urban functions.

In framing a relocation strategy it is important therefore to distinguish functions which are sea port dependent from other functions and to distinguish functions in terms of their significance for the regional economy. As part of a rapid assessment exercise for purposes of this report economic activities in the town were classified into 16 groups. Economic activities were also classified according to whether they are region or province servicing in the case of the public sector and whether they are large (15 plus employees and likely to do business beyond ENB) or medium (5-14 employees and likely to operate largely within ENB). Smaller establishments in both the public sector (eg primary schools) or in the private sector (eg trade stores) were not considered because they are likely to follow and service the population associated with larger employers.

A total of 153 establishments were included in this analysis accounting for direct employment of 3 476 with 50 establishments in the public sector and 103 in the private sector. Some very rough working assumptions are needed to scale these figures up to account for the rest of the workforce and to yield a population equivalent.

In the first place it is assumed that small scale establishment in the private and public sectors account for some 50% of the total workforce and that accordingly the total workforce is in the vicinity of 7 000. Secondly it is assumed that the employee/population ratio is 2.5. This is lower than the household size figures because of the unusually high in-commuting patterns applying in Rabaul. The breakdown of employment by economic activity, sector and orientation (region serving and province serving) is shown along with population equivalents in Figures 18 and 19 below

Considering only establishments at higher levels in the service hierarchy (regional and provincial for the public sector and large and medium for the private sector). Table 29 accounts for some 3 500 of the workforce and 8 700 of the population of Rabaul. Assuming that smaller sized establishments account for some 50% of the workforce and that employment at this level in the hierarchy is 'population following' a factor of 2.0 can be used to scale up direct population figures for each group (the columns or rows in Table 18) to get a total population estimate. On this basis the employment converts to a estimated workforce for Rabaul of 6 950 or a total population of 17 370 which is a satisfactory approximation to the actual 190 population of 17 040. The estimated population of Rabaul for each level of relocation is shown in Table 19.

TABLE 18 - ECONOMIC ACTIVITY BY SECTOR AND SCALE
-DIRECT EMPLOYMENT AND POPULATION EQUIVALENT

Activity	Public		Private		Direct	
	Region	Prov	Large	Medium	Emp	Pop
1. Warehouse and Dist	115	15	310	50	490	1 225
2. Agric Proc and Trade	0	0	80	0	80	200
3. Manuf	0	0	150	10	160	400
4. Transport-Sea			120	35	155	388
5. Prof Service		30	60	35	125	312
6. Eng and Tech Serv	50	50	380	60	450	1 350
7. Vehicles - Sales				10	10	25
8. Finance and Banking	20	130	205	75	430	1 075
9. Retail		50		230	280	700
10. Tourism and Hotels	5		100	30	135	338
11. Transport Air	170		60	15	245	612
12. Transport Land	0	0	70	40	110	275
13. Comms and Media	70	35	10	50	165	412
14. Health Educ, Welfare	50	155	0	0	205	512
15. Com Fac and Enter	0	15	25	25	65	162
16. Other Govt	55	225	0	0	280	700
Direct Employment	535	705	1 570	665	3 475	
Pop Equivalent	1 340	1 760	3 925	1 660		8 685

TABLE 19 - LEVELS OF RELOCATION

Level	Activities Relocated	Direct Employ	Direct Pop	Pop Reloc	Pop in Rabaul
Rebuild	none	no change	no change	none	17 500
Low	all region serving public sector activities except wholesaling and distribution	420	1 050	2 100	15 400
Medium	as above plus same activities for provincial government	690	1 725	3 450	11 950
High A	as above plus all prof services, finance and trade, transport (air), comm and media, and 50% of eng. and tech services, tourism and transport and community facilities for medium sized private sector activities	483	1 208	2 415	9 535
High B	as above including large private sector enterprises	623	1 558	3 115	6 420

There are undoubtedly errors in the data used in this analysis and in the categorisation of enterprises and establishments. These can be corrected at a later stage. The figures as they now stand can however be used to indicate broad magnitudes and to illustrate method.

The above relocation levels have been conceived to yield increasing levels of risk reduction (population numbers relocated) by first relocating activities which are non sea port dependent, which are in the public sector and therefore more subject to influence and to activities which have suffered extensive damage in the eruption. Activities which are seaport dependent, which have suffered little damage or which are in the private sector, are the last candidates for relocation.

The damage assessment reveals that medium sized private sector enterprises were mainly clustered in the commercial areas of the north east and east of the town and suffered almost complete destruction. A majority of these enterprises could not be said to be strongly sea port oriented. Province serving establishments are clustered in three locations around the commercial area and suffered similar levels of destruction. Only one or two provincial government establishments appear to be strongly sea port oriented. A high proportion of the larger private enterprise establishments are strongly sea port oriented and these as a general rule suffered least destruction from the eruption. With obvious clear exceptions, region - serving public sector activities were not strongly sea port oriented, which makes them suitable candidates for relocation. On the other hand they were not clustered in any particular part of town and do not fit any clear damage pattern.

On balance then the composition of each level or relocation fits reasonably well with the criteria indicated above and the levels of population reduction involved provides a useful range of alternatives for consideration.

4.3.4. Approaches

Given the scale and complexity of the work to be undertaken, the political sensitivity of the issues involved and the modest local resources available the only workable approach appears to be to proceed slowly and carefully.

Relocation would rely on existing methods of land administration for example and on local resources as far as possible. Temporary solutions would be used to buy time until resources were available.

The risk with this approach is that having aimed low there will be difficulty attracting even minimal assistance; local resources will then become over-stretched and redundancy, waste and expensive Yremedial action will mean that the process will end up absorbing greater resources for poorer results.

The alternative approach is to attach relocation head on and early. It is essential to develop ambitious programmes and set realistic targets. Large contract packages will be of interest to multilateral agencies and big contractors. Focus should be on local political control of the broad agenda rather than detailed technical an administrative control of all activities.

It is likely that such an approach will allow the province to hold a majority of the small businesses which might otherwise fade away and it should help to attract essential donor assistance and financial support for investment in the province.

These arguments are summarised in point form in Table 20.

TABLE 20 - APPROACHES TO RELOCATION

Approach	Features	Likely Outcome
'practical'and long term	Long term process temporary solutions existing methods mainly own resources local technical control	overload provincial technical and administration resource revert to rebuild Rabaul waste and redundancy extra trauma for community lose small business and regular clients community frustration, uncertainty and tension
Large scale and rapid	heavy reliance on assistance large contract components tight/reasonable target dates temporary solutions to a minimum new capability in land management	donors and late investors will support ambitious programme with solid risk minimisation component small business and regular clients not lost community will tolerate hardship if progress evident and end in view

4.4. ELEMENTS OF A STRATEGY

The following points are submitted for consideration in framing a broad strategy for re-establishing the urban functions which were damaged or destroyed in the September eruption.

4.4.1. Approach

Higher order service functions for the island region should continue to be based in East New Britain.

Rabaul Harbour should be re established as the island region's principal port. Rabaul airport should be relocated to Tokua and runway and ground facilities should be upgraded/established as a matter of urgency. Lakunai airport should be permanently closed for commercial operations.

In order to reduce risk to future urban residents many of the urban functions of Rabaul should be relocated to a lower risk site which is accessible to the airport.

These functions should be concentrated in an urban centre capable of very rapid expansion to accommodate a Stage 1 population of some 15 000 and an ultimate population in the small/medium city size range of 50 000.

The public sector should take the lead in relocating all its activities which are not directly sea port related and should encourage non sea port related, private sector activities to relocate.

The private sector should not be compelled to relocate and there should be no use of planning or other regulatory controls to prevent development in the town of Rabaul. The objective here is to establish as much certainty as possible about the future pattern of development while avoiding the kind of unproductive conflict and litigation over entitlements in land which will happen if to much use is made of regulatory powers.

Measures to encourage the private sector to relocate and to reduce risk for those which re establish in town include:

- assistance with land pooling and transfer arran gements for land owners wishing to relocate
- fast tracking of approvals for development of sites for small businesses relocating to the preferred urban centre
- giving high priority in infrastructure programming to restoration of services for port related activities and low priorities for all other activities re establishing in Rabaul
- encouraging the establishment of a disaster insurance levy scheme with coverage limited to port related activities.

The relocation programme should target for special assistance groups which have both suffered heavy loss in the eruption and will experience major difficulty in re-establishing themselves. Residents of the villages fringing Rabaul town and small business groups require particular attention.

Kokopo could be adopted now as the preferred relocation venture with a high degree of confidence. If it is considered necessary, on political grounds, to establish this point conclusively then a technical study of a short list of sites using specific technical, economic and social criteria and operating within a deadline of a few weeks could be undertaken.

4.5. AN URBAN DEVELOPMENT PROGRAMME

A figure of 15 000 should be adopted as a previsional target for Stage 1 planning purposes for Kokopo. It is assumed that a complementary rural resettlement programme will be developed with the urban and the rural programmes accounting for all households requiring settlement after the initial emergency care centre numbers have declined and stabilised. This figure allows for both relocation from Rabaul township and from the fringe villages.

The work of preparing an urban plan for Kokopo and revising the plan for Rabaul must not proceed in isolation. These plans will have to go beyond conventional land use plans and provide guidance on the staging of development, the programming of infrastructure provision and the development of community faculties. The two plans will have to be prepared with consistent assumptions about the location timing and type of development to occur in each centre if wastage, confusion and delays are to be avoided.

Accordingly it is proposed that an Urban Development Programme be prepared covering both urban centres. This would comprise:

- a broad statement about the overall amount, type, timing and mix of development to be planned for in each of the centres and the staging of this
- a consolidated programme of sectoral investment plans for Provincial and National agencies would be prepared in support of this policy statement.

The policy statement part of the Programme should be a short policy type document setting out areas of agreement between the different levels of government. The consolidated programme would be more of a technical document setting out areas of agreement between agencies about the amount and timing of their inputs to the relocation programme. The programme should be updated and revised at regular intervals.

The programme could be given the status of a provincial physical plan under Section 46 of the Physical Planning Act (1989). The proposed Reconstruction Authority should be made the responsible authority for purposes of preparing and administering the Programme.

4.6. INSTITUTIONAL ARRANGEMENTS

The relocation programme should be conceived as a major project requiring extraordinary funding and dedicated high level political and management skills. It should not be left to be undertaken as an extra task by line agencies. Elements of the management task are:

- mobilisation of agency, donor and private sector finance and technical assistance
- generation of structure plans, infrastructure programmes, large contracting packages for land and housing development and institutional, small business and community facilities to very tight timelines
- avoidance of temporary solutions
- proactive land management including development of a disaster levy scheme, land pooling and transfer arrangements, creative housing finance packages
- community relations and community development activities.

A proactive rather than a regulatory approach to land management will be critical to the success of a relocation program. A range of skills are involved including housing finance, infrastructure programming, structure planning, public relations, real estate, physical planning and community development. These skills could be located in a development corporation forming the implementation arm of the Reconstruction Authority.

The Authority, the Corporation and the Programme should have a defined time horizon of say 5 years and they should be the implementing structures through which donor and multilateral assistance is channelled.

Project preparation assistance should be sought from donors for preparation of the Urban Development Programme and a supporting series of implementation packages.

Land price stabilisation measures should be applied to ensure that speculative dealings in land do not frustrate the objectives of the relocation programme and that cross subsidies which are deemed desirable in order to assist particular groups are transparent and justified.

4.7. KOKOPO

The terms of reference for preparation of the Urban Plan for Kokopo were drafted prior to the eruption. Consultants for the study have now been engaged.

The Urban Development Programme could be used to provide a strong basis for the detailed planning to be undertaken in Kokopo. If the development programme concept is adopted, the consultant's work programme and planning assumptions would need to be brought into line with the requirements of the programme.

A workable structure plan must be prepared for Kokopo as quickly as possible setting out land use, movement systems, infrastructure headworks and major facilities for a nominal planning horizon and a broad staging plan for the achievement of this.

Work should proceed in parallel on detailed planning for Stage 1 land development and housing construction. For these purposes the Housing Corporation's proposal for a substantial housing project at Kokopo should be reviewed with a view to urgent implementation.

4.8. RABAUL

For the moment planning activity in Rabaul should be limited to measures in support of public health and safety. Development control powers should be exercised subject to advice on strategies for minimisation of risks from mudflows. Applicants should be advised that a major relocation of urban activities is being actively considered by government. Amendments to building codes should be prepared to provide for ash loadings. Demolition orders should be served on structures which have suffered irreparable damage.

Once eruption activity has subsided and mud flow strategies are in place applications could be approved subject to reconnection of water and electricity and/or compliance with building codes as appropriate.

As a low priority activity redevelopment and land pooling options should be prepared to best match services and facilities remaining in the town to likely long term development patterns.

5. PROJECT PACKAGES AND OTHER ISSUES

5.1. GENERAL RECOMMENDATIONS

The following projects, as detailed in Appendix 3, are suggested for implementation, after consideration of relocation issues and immediate and future requirements.

		Indicative Cost
R1	Kavavar/Kurakakaul Road Upgrade	K1.5 m
R2	ELCOM housing	K2.5 m
R3	Rabaul town access	K0.5 m
R4	Rabaul Town Road Rehabilitation	K7.0 m
R5	Kokopo and Burma Road Rehabilitation	K2.5 m
A1	Tokua Airport Upgrade (to F28 Standard)	K1.5 m
A2	Mains Electricity for Tokua Airport	K0.3 m
A3	Generators for Tokua Airport	K0.1 m
A4	Water Bore/s for Tokua Airport	K0.08 m
A5	Navigation Aids for Tokua Airport	K1.0 m
A6	Weather Monitoring Equipment for Tokua Airport	K1.0 m
A7	Radio Equipment for Tokua Airport	K0.6 m
A8	Staff Housing at Tokua Airport	K4.0 m
A9	Maintenance and Stores Buildings at Tokua Airport	K0.5 m
A10	Control tower for Tokua Airport	K0.5 m
A11	Administration Building at Tokua Airport	K0.3 m
W1	Generators for bores at Rabaul and Nonga	K0.8 m
W2	Repairs to water mains and services	K0.15 m
W3	Water Board office and equipment	K0.3 m
W4	Water Board Stores and Workshop	K0.3 m
W5	Water Board Housing	K.02 m
W6	Cleaning and Repairs to Rabaul Sewerage System	K0.15 m
W7	Rural Water Supplies	K1.2 m
EL1	Repair Elcom Transmission Lines	K0.7m
EL2	Repair Elcom Distribution Lines	K0.2 m
EL3	Remove Ash from Cables, Insulators etc	K1.5 m
EL4	Repair Elcom office	K0.3 m
EL5	New Elcom Store and Workshop	K0.4 m
EL6	Elcom Housing	K2.5 m
EL7	Consolidate Diesel Generators at Kokopo	K3.0 m
T1	New Telephone Exchange and Business Office	K5.0 m
T2	Electricity Supply to New Exchange	K0.1 m
T3	Water for New Exchange	K0.05 m
T4	T4 New Telikom Stores and Workshop	K0.8 m

		Indicative Cost
T5	New Transmitter Building In Rabaul	K1.2 m
T6	Underground Cables	K3.0 m
T7	PTC Housing	K2.0 m
P1	New Post Office	K1.2 m
RA1	New NBC Studio	K0.5 m
RA2	Re-roof Building at Kuakakaul Transmitter	K0.05 m
RA3	Complete Project - Radio Link to North Solomon	-
RA4	NBC Staff Housing	K0.6 m
E1	Community School Temporary Buildings	K1.0 m
E2	Community School Permanent Buildings	K2.0 m
E3	Provincial High School Temporary Facilities	K0.8 m
E4	Provincial High School Permanent Buildings	K1.4 m
E5	Displaced Primary Student Education	K1.8 m
E6	Education Materials and Office Equipment	K1.0 m
E7	Rabaul Technical HS Reconstruction	K1.1 m
E8	Relocate CODE Office	K0.5 m
E9	Repair Public Library	K0.65 m
E10	Tok Ples Skul	K0.02 m
E11	Rabaul Girls Vocational School	K0.4 m
H1	Assist Immunisation Programme	K0.3 m
H2	Vunapope and Butuwin Hospital Upgrade	K0.3 m
H3	Nonga Base Hospital Refurbishment	
H4	Assist Health Education Programme	K0.25 m
H5	Health Impact of Eruption Study	K0.005 m
H7	Butuwin Health Centre Upgrade	K0.33 m
H8	Rabaul Clinic Reconstruction	K0.3 m
H9	Settlement Areas Health Centres	K0.32 m
H10	Regional Health Staff Repatriation	K0.01 m
H11	Handicapped Rehabilitation Centre	K0.06 m
H12	Supply of Office and Medical Equipment	K0.5 m
L1	Tomaringa Police Barracks Upgrade	K2.0 m
L2	Nodup Police Post	K0.05 m
L3	Equipment and Materials	K0.7 m
L4	Reconstruct Rabaul Police Station	K0.7 m
L5	Reconstruct Police Barracks at Malaytown	K4.7 m
L6	Reconstruct Courthouse	K0.6 m
PG1	Reconstruct Prov. Govt. Complex, Kuanua Street	K1.2 m
PG2	Reconstruct Provincial Assembly Complex	K0.7 m
PG3	Reconstruct Prov. Govt Vesters Street Complex	K0.45 m
PG4	Reconstruct Lands and Forests Complex	K0.9 m

		Indicative Cost
PG5	Reconstruct Education Complex in Malaguna Street	K0.35 m
PG6	Supply Office Equipment	K0.55 m
NG1	Reconstruct National Disaster and Emergency Centre	K0.08 m
NG2	Reconstruct National Housing Commission Office	K0.03 m
NG3	Reconstruct DOW Vehicle Workshop and Provincial HQ	K2.6 m
NG4	Reconstruct Fire Station	K0.25 m
NG5	Supply Office Equipment	K2.0 m
NG6	Supply and Install Volcano Monitoring Equipment	K1.8 m
NG7	Restore Government Housing	K17.0 m

Details of the problems and proposed solutions for each government sector are provided in Tables 11 to 20. The problems are generally limited to infrastructure and government sectors. There are numerous other problems as a result of the eruption but these are outside the scope of this study.

Details of the projects designed to implement the solutions are provided in Appendix 3. Equipment and materials supply projects are also described in Table 21.

5.2. ROLE OF DONORS

Considerable scope exists for the participation of donors in the reconstruction of Rabaul.

Specific areas in which donors could assist include:

- design and implementation of projects described in Appendix 3. The projects provide for the procurement of materials and equipment and for capital works reconstruction and construction
- provision of emergency supplies for displaced persons
- programme planning and project design for the relocation of certain functions once the GOPNG selects one of the function relocation options proposed in this report.
- support for communities which are temporarily or permanently resettled by the PNG government
- trauma counselling
- targeted support to facilitate the reconstruction of damage to private sector buildings and facilities.

The World Bank has undertaken a preliminary mission to PNG to consider the scope of possible assistance and plans a further visit in December 1994. The Bank has indicated that existing PNG loans which have not been utilised to date may be redirected to assistance in the same sector in East New Britain and has provided a notional figure of approximately $US30 million as being available for relocation. The Asian Development Bank has provided to PNG a $US500 000 Emergency Loan to assist with immediate reconstruction needs and has indicated its preparedness to assist in the long term reconstruction process. The Australian Government and the European Community are major donors to PNG and both have stated to the PNG Government and in public that they are willing to make a

major contribution to the reconstruction programme. The Japanese Government has been involved in a number of major projects to date in East New Britain Province and is also a potential donor to the reconstruction program.

Donor funding is likely to be central to the viability of the reconstruction programme and with a number of major donors likely to be involved, donor coordination will be an essential role for the PNG Government. Specifically, it is expected that donor coordination and liaison would form a major task for the proposed Reconstruction Authority recommended in Section 4 of this report".

5.3. TECHNICAL ASSISTANCE

During the reconstruction of Rabaul there will be a need for technical expertise in a wide range of disciplines. Areas in which the international community may be requested by the GOPNG to provide assistance are:

- development and implementation of a land management strategy including land pooling options.
- development of earthquake and volcano damage insurance schemes and other urban land and private sector assistance
- preparation of strategies for the development of new industries in Rabaul
- reconstruction programme planning and management
- project design, management and monitoring for reconstruction and relocation projects
- development of appropriate funding mechanisms for the reconstruction programme
- installation of new equipment for the Rabaul Vulcanological Observatory
- economic sector damage assessment, especially agriculture
- assessment of the health implications of long term exposure to volcanic ash and dust
- rehabilitation of the Rabaul electrical reticulation network eg specialised cleaning technology, corrosion protection
- redrafting of building codes to protect against ash loads
- trauma counselling

5.4. EQUIPMENT AND MATERIALS

Details of specific projects for the supply of materials and equipment are included in the list of projects provided in Tables 22 to 31. Table 21 below identifies specific equipment and materials supply projects identified to date.

TABLE 21 - EQUIPMENT AND MATERIALS SUPPLY PROJECT

Project Name	Project No
Navigational Aids Tokua Airport	A5
Weather Monitoring Equipment Tokua Airport	A6
Radio Equipment Tokua Airport	A7
Generators for the Water Board	W1
Supply of Office and Medical Equipment	H12
Law and Order Equipment and Materials	L3
Office Equipment for Provincial Government	PG6
Office Equipment for National Government	NG5
Volcano Monitoring Equipment	NG6
Educational Materials/Books	E6

Supply of materials and equipment is also included in a number of capital works and technical assistance projects. Details of the scope of works is provided in Appendix 3.

5.5. SOLUTIONS TO PROBLEMS

The following tables list problems and proposed solutions for each government sector. These solutions are elaborated in the project descriptions in Appendix 3.

TABLE 22 - LAND TRANSPORT PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Project No
Land Transport	Kokopo Rd and Burma Rd damaged by ash and subject to flood damage.	1 Upgrade and seal the Kavavar to Kurakakaul Rd. 2 Upgrade the Ramale to Vunavutung Rd 3 Repair the Kokopo and Burma roads at the end of the wet season.	R1 R2 R5
	Reimber community roads damaged by ash fall and flooding.	1 Carry out emergency maintenance to carriageway and drainage. 2 Resheet Vunalaka/Kurakakaul Rd 3 Resheet Iatapal/Vunadir 4 Emergency maintenance to minor roads	R2
	Rabaul Town roads damaged by ash fall and mudflows.	1 Maintain limited access to town until the end of the wet season with the exception of access to the wharf and those businesses operating in the western end of town.. 2 Construct berms to protect undamaged or slightly damaged buildings. 3 Rehabilitate roads at the end of the wet season.	R3 R4

TABLE 23 - AIR TRANSPORT PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Proj. No
Air transport	Airport at Rabaul is destroyed	1. Relocate airport to Tokua	A1
	Access road to Tokua is inadequate	1. Upgrade Tokua access road	A1
	No water at Tokua	1. Sink bore/s at airport	A4
	No electricity at Tokua	1. Provide generator/s 2. Bring in mains electricity	A2, A3
	Navigation equipment is inadequate	1. Provide visual landing aids eg. t/vasis 2. Provide landing lights 3. Provide aerodrome beacon lights 4.Provide other navigation equipment as required	A5
	Weather monitoring equipment is inadequate	1. Provide satellite and other weather monitoring equipment	A6
	Radio equipment is inadequate	1. Provide new radio communication equipment	A7
	No staff housing	1. Provide staff housing	A8
	No storesheds or workshops	1. Construct buildings	A9
	No control tower	1. Construct control tower	A10
	No administration building	1. Construct DCA administration building	A11

TABLE 24 - WATER SUPPLY AND SANITATION PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Proj. No
Water supply	No water supply at Rabaul	1. Restart pumps at bores 2. Repair water mains 3. Repair and.or disconnect property extensions	W1,W2
	No electricity to drive pumps	1. Provide generators 2. Restore mains power	W1, EL1, EL2, EL3
	No water supply at Nonga	1. Restart pumps at bores	W1, EL1, EL2
	Office and office equipment inadequate	1. Provide office and equipment	W3
	Insufficient staff housing	1. Provide staff housing	W5
	No workshop or store	1. Provide buildings for these purposes	W4
	Insufficient water in areas currently housing or proposed to house displaced people	1. Provide bores, pumps and reticulation as necessary	W7
Sewerage	Sewerage system in Rabaul not working	1. Clear outfall from Imhoff tank 2. Clean out Imhoff tank 3. Test and repair sewers 4. Restart pumps 5. Disconnect or repair property connections.	W6
	No workshop or store	1. Same as for water supply (above)	W4

TABLE 25 - ELECTRICITY PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Proj. No
Electricity	No electricity in Rabaul	1. Repair and clean 22 kV line on north coast 2. Repair and clean 66 kV line on Kokopo and Burma roads 3. Repair and clean distribution lines 4. Disconnect property services 5. Clean and restart generators in Rabaul 6. Inspect and certify wiring before reconnection	EL1, EL2, EL3
	Office and equipment is damaged	1. Repair office 2. Provide office equipment	EL4
	Store has collapsed	1. Construct new store	EL5
	Not enough staff houses	1. Construct more staff houses	EL6
	Ash is conducting electricity at insulators	1. Clean insulators	EL3
	Corrosion is affecting overhead cables	1. Clean cables	EL3
	Generators in Rabaul may be subjected to further volcano damage	1. Relocate Rabaul generators to Kokopo and consolidate them there with the generators from Kerevat	EL7

TABLE 26 - COMMUNICATIONS PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Proj. No
Telephones	Exchange building and equipment destroyed	1. Relocate to new site 2. Erect new exchange building 3. Provide and install new exchange equipment	T1
	Electricity supply at new site uncertain	1. Upgrade mains supply as necessary 2. Clean and relocate generator from Rabaul exchange	T2
	Water supply at new site uncertain	1. Provide mains water 2. Sink bore	T3
	Stores building has collapsed	1. Build new stores building	T4
	Transmitter building has collapsed and its equipment destroyed	1. Build new transmitter building 2. Provide new transmitting equipment 3. Clean masts and antennae	T5
	Underground cables are probably damaged	1. Regas and test in sections 2. Replace damaged sections 3. Investigate most appropriate types of cable for future use (eg fibre optic)	T6
	Not enough staff housing	1. Construct staff houses	T7
Postal service	Post office collapsed	1. Construct new Post Office of more durable design and provide furnishings and equipment	P1
Radio	NBC studio collapsed and equipment is destroyed	1. Relocate studio to a safer place 2. Construct new studio 3. Provide studio equipment	RA1
	Roof on building housing expensive equipment at Kuakakaul is corroding	1. Replace roofing material	RA2
	Antenna for AIDAB project at Kuakakaul is lying on the ground and the mast is covered in ash	1. Clean mast and antenna 2. Erect antenna	RA3
	Not enough staff houses	1. Construct staff houses	RA4

TABLE 27 - EDUCATION PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Project No
Education	Community school buildings, equipment and materials damaged.	1 Provide temporary buildings(perhaps tents initially) and double shifts during 1995. 2 Replace damaged equipment and materials and books. 3 Provide permanent buildings in locations to suit population location	E1 E2 E6
	Provincial High School buildings, equipment and materials damaged.	1 Catholic Education Agency advise on alternative to St Mary's School 2 Provide temporary buildings(perhaps tents initially) and double shifts during 1995. 3 Replace damaged equipment and materials. 4 Provide permanent buildings in locations to suit population location	E3 E4 E6
	Education of displaced children.	1 Provide temporary buildings(perhaps tents initially) 2 Provide equipment and materials.	E5
	CODE office destroyed	1 Relocate staff to alternative facility on the mainland. 2 Reconstruct facilities in Rabaul	E8
	Rabaul Business College damaged	1 Repair dormitories and some classrooms 2 Provide temporary facilities for administration staff, kitchen and teacher housing. 3 Provide replacement equipment and materials 3 Construct permanent facilities	E7
	Public Library Damaged	1 Repair existing building 2 Provide replacement books and office equipment.	E9
	Tok Ples Skul Damaged	1 Relocate offices to temporary facilities. 2 Replace damaged equipment and materials	E10
	Rabaul's Girl Vocational School	1 Relocate students and teachers to other Vocational Schools. 2 Replace damaged materials and equipment 3 Reconstruct school with permanent buildings.	E11

TABLE 28 - HEALTH PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Project No
Health	Maintain health of community during crisis	1 Immunisation of risks groups. 2 Investigation of health risks associated with eruption. 3 Trauma counselling 4 Health education programme 5 Maintain Health Statistics unit	H1 H4 H5 H12
	Cool storage for vaccines	Provision of cool store at Vunapope	H1
	Loss of hospital facilities through closure of Nonga Base Hospital	1 Construct additional facilities at Vunapope Hospital to act as provincial hospital. 2 Regional referrals to mainland hospitals 3 Repair damage to Nonga Base Hospital	H2 H3 H7
	Loss of provincial services with closure of Rabaul Clinic Complex and damage of staff housing..	1 Provide temporary offices at Butuwin Health Centre. 2 Provide office and medical equipment damaged. 3 Reconstruct Rabaul Clinic. 4 Reconstruct damaged houses.	H7 H8 H12 NG7
	Health Care to displaced persons until relocation to permanent location	1 Establish Health Centres adjacent to semi permanent resettlement areas. 2 Provide accommodation for Medical Staff at Health Centres.	H9
	Lack of facilities for Div of Health staff due to damage of Matupit St offices and housing.	1 Provision of temporary offices at Bukuwin Health Centre 2 Provide replacement office equipment 3 Provide temporary housing for staff at Kokopo. 4 Reconstruct permanent offices 5 Reconstruct damaged staff houses.	H7 H12 PG6 NG7
	Lack of facilities for Dept of Health staff due to damage of Matupit St offices and housing.	1 Relocation of regional functions to mainland and repatriation of staff. 2 Reconstruct permanent offices. 3 Reconstruct damaged staff houses.	H10 PG6 NG7
	Proposed handicapped persons rehabilitation centre damaged	1 Reconstruct damaged building.	H11

TABLE - 29 LAW AND ORDER PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Project No
Law & Order	Rabaul Police Station damaged.	1 Relocate Provincial and Divisional HQ to Tomaringa Barracks. 2 Provide watchhouse at Tomaringa. 3 Replace damaged specialist and general office equipment. 4 Provide police post at Nodup 5 Carry out police patrols of North coast area. 6 Reconstruct Rabaul Police Station	L1 L2 L3 L4
	Police Barracks at Malay town destroyed.	1 Repatriate non ENB married police to their provinces. 2 Recruit single police or ENB officers. 3 Relocate to temporary accommodation at Tomaringa 4 Reconstruct barracks at Malaytown	L1 L5
	Court House and other justice offices damaged	1 Relocate District and National court to alternative premises 2 Repair court house building 3 Replace damaged office equipment	L3 L6
	Police houses damaged	1 Relocate on temporary basis to Tomaringa 2 Repair or reconstruct existing houses.	NG7
	Legal officers houses damaged	1 Relocate on a temporary basis to alternative houses 2 Repair or reconstruct damaged houses.	NG7

TABLE 30 - PROVINCIAL GOVERNMENT PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Project No
Government Administration Provincial	Provincial complex in Kuanua St damaged.	1 Relocate staff to temporary offices in Vunadidir and Kokopo 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment.	PG1 PG2
	Provincial Assembly complex damaged.	1 Relocate staff to temporary offices in Vunadidir and Kokopo. 2 Reconstruct and repair damaged buildings. 3 Replace damaged office equipment.	PG2 PG6
	Vesters St complex damaged	1 Relocate staff to temporary offices in Vunadidir and Kokopo 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment.	PG3 PG6
	Lands & Forests complex	1 Relocate staff to temporary offices in Vunadidir and Kokopo 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment.	PG4 PG6
	Education offices Malaguna St	1 Relocate staff to temporary offices in Vunadidir and Kokopo 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment.	PG5 PG6
	Staff houses destroyed	1 Staff relocated to temporary accommodation 2 Reconstruct and repair houses	NG7

TABLE 31 - NATIONAL GOVERNMENT PROBLEMS AND SOLUTIONS

Sector	Problem	Solution	Project No	Location
Government Administration National	National Disaster and Emergency Service offices damaged	1 Relocate staff to temporary offices. 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment	NG1 NG5	
	National Housing Commission office damaged	1 Relocate staff to temporary offices. 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment	NG2 NG5	
	Dept of Works offices in Malaguna St damaged.	1 Relocate staff to temporary offices in Kokopo 2 Reconstruct and repair damaged buildings 3 Replace damaged office equipment	NG3 NG5	
	Fire Station Damaged	1 Relocate staff to temporary offices at Kokopo 2 Reconstruct and repair damaged buildings 3 Replace damaged equipment	NG4 NG5	
	Rabaul Vulcanological Observatory equipment damaged	1 Provide replacement equipment to adequately monitor and explore the volcano network in PNG	NG6	
	Staff houses destroyed	1 Staff relocate to temporary accommodation 2 Reconstruct and repair staff houses.	NG7	

APPENDIX 1

TERMS OF REFERENCE

(DRAFT)

TERMS OF REFERENCE

FOR A

TECHNICAL ASSESSMENT OF THE RECONSTRUCTION NEEDS FOR THE RABAUL TOWNSHIP AND SURROUNDING AREAS OF EAST NEW BRITAIN

PREPARED BY AIDAB

OCTOBER 1994

1. BACKGROUND

Rabaul, the Provincial capital of East New Britain, has been built on a vast volcanic crater which has three active volcanoes inside it. The enormous crater also forms a safe, natural harbour for the town, and in the hundred years or so since the establishment of the Rabaul the town has grown extensively around the foreshores of this harbour. In recent history, Rabaul has been seriously affected by volcanic eruptions on a number of occasions. In 1937 serious damage and loss of life was caused by a major eruption of the volcanoes; during 1948 a period of very high seismicity and ground deformation was expected to lead to a similar scale of eruptions but, fortunately, this did not occur. Nevertheless, this 1984 experience led to the development of a comprehensive strategic plan for the town, both for evacuation in the event of a major eruption and for longer term regional development.

On September 19, 1994, a volcanic earthquake triggered the eruption of the two most active volcanoes adjacent to Rabaul, Vulcan and Tavuvur. Rabaul was evacuated during the course of the following two days and people moved to safe shelter points in the nearby settlements, principally in the area around the nearby township of Kokopo. A State of Emergency was declared and assistance was requested by the PNG government sought for shelter, food and water for the affected populations, which were estimated to number up to 100,000. The volcanic activity continued for a number of a days after the initial eruption then gradually started to diminish, allowing authorities to commence some clean up operations and restoration of access to areas within the township. Some damage assessment of buildings and has commenced but there is a need to assist the authorities in the Province undertake a more comprehensive assessment of the extent of the damage and to identify priority areas and needs for reconstruction.

The Australian Government and other donors have been quick to respond to the disaster with emergency supplies and the provision of emergency air transport. Close liaison was developed between AIDAB and the Provincial authorities in the identification and delivery of this assistance. In terms of the longer term needs an offer to assist in the needs assessment for the reconstruction program was made by AIDAB. This mission is the first stage in the development of a long-term program for reconstruction/rehabilitation support from Australia and other donors for the reconstruction for East New Britain Province.

i) Rabaul Town situation

Broadly speaking, the extent of the damage to Rabaul Town varies with distance from the Matupit Crater. The airport and Malay Town areas as far north as Namanula Road are covered by ash in excess of 1 metre and it is estimated 80 - 90% of buildings have been damaged beyond repair. The Central Business District (along Mango Avenue from Namanula Road to Malaguna Road) is covered by ash up to 1 metre of ash and possibly 50% of structures in this sector have been severely damaged. The area along Malaguna Road to Tunnel Hill is covered by ash

of varying depths, generally about 10 cm to half a metre and only about 10% of structures have destroyed.

Heavy ash cover and destruction of vegetation on the northern and eastern walls of the caldera present a further hazard. In the event of heavy rains (due November-December) mudslides are highly likely, which would threaten several areas of the town.

Power and communications infrastructure appears to have been extensively damages and could require a major reconstruction effort. The situation regarding other services, such as water and sewerage networks, will remain unclear until testing can be undertaken.

ii) The Provincial Government and Local Community role

It was well understood prior to the 1994 eruption that the development of Rabaul Town was threatened by volcanic activity and for this reason the ENB Provincial Planning Board had already commenced the process of preparing a 20 year Kokopo Town Development Plan. The Terms of Reference for this plan envisaged the development of Kokopo as a twin municipality to Rabaul and refer to the proposed relocation of government and related services to Kokopo. The PNG Government has not formally made a decision on the relocation of government facilities, but there is a strong view that some infrastructure developments should be relocated to safer sites.

In the wake of the current disaster the Director of the Provincial Disaster Coordinating Committee (PDCC), who is also the Provincial Secretary, has indicated a preference that planning for new urban development at Kokopo proceed as soon as possible. This view is also shared by other leaders in the Province and is being positively canvassed in discussions at the national level. The redevelopment of the Tokua Airport, recommended as part of the 1984 strategic plan for the area, is also being discussed as a necessary part of the reconstruction process. However, there is a widely held view that the port and the associated facilities remain at the current location in Simpson Harbour, as there is no suitable alternative site in the area.

The PDCC are still heavily preoccupied with the management of the State of Emergency and the ensuring the health and welfare of the displaced population. Resources available for early consideration of restoration issues are limited. However, the business community is already returning to the town and is expected to begin making commercial decisions on relocation and reconstruction matters in the near future. There is also a need to re-establish essential services quickly, although the level of service required will need to be assessed in the light of proposals to relocate functions to Kokopo or other areas.

It should be noted that the issue of the relocation of part of the functions of Rabaul town to the eastern Gazelle area would directly affect only a small percentage of the population, about 20,000 (the previous population of Rabaul town). The remainder of

the population of the Gazelle Peninsular (approximately 100,000) live in rural villages and hamlets on custom land. As there is virtually no unused tracts of custom lands available to communities in the Gazelle area, the vast majority of the people will have no option but to return to their villages. Alternatively, the Provincial Government is understood to be considering the purchase of plantation land to resettle the most affected populations.

iii) The Kokopo Town Development Plan.

In considering the issue of redevelopment and reconstruction it will be essential for the technical assessment mission to take account of the strategy contained in the proposed Kokopo Urban Development Plan Terms of Reference and to consider priority activities for donor funding and support in the light of any decisions that may be made arising out of this plan.

In brief, the Terms of Reference for the Kokopo Urban Development Plan propose the preparation of a comprehensive 20 year urban development plan in three phases over a six month period. The Provincial government is understood to have selected a consultant to undertake the work under the supervision of a Steering Committee comprising the Provincial Planning Committee, business representatives, National Government agencies and Local Government Councils. The three phases are:

i) Collect baseline data including, but not limited to, physical feature, land tenure, demographic information, current urban development and physical, social and transport infrastructure;
ii) Produce projections of likely population growth and urban development based on the baseline data and specific development proposals and recommend alternative development strategies for the growth of Kokopo over the next 20 years; and
iii) Following the endorsement by the Steering Committee of a strategy, prepare the necessary maps, documentation, costings, an urban investment plan and a strategy for implementation.

The complete Terms of Reference are available from the Department of Lands and Physical Planning.

2. OBJECTIVES AND SCOPE

The objective of the mission are:

i) to undertake an initial assessment of the damage to infrastructure in the Rabaul area;
ii) to document the level of repairs or reconstruction that is required for key infrastructure facilities including service facilities;
iii) to report on the level of assistance being provided to rural communities following the disaster; and

iv) to develop recommendations for donor assistance based on a long-term assessment of the priority reconstruction needs for both the Rabaul and Kokopo areas.

In fulfilling the above objectives, the mission will be required to identify information and data requirements that will assist in the development of reconstruction planning and to prepare terms of reference or scopes of works for follow-up investigations and design work to allow reconstruction activities to proceed efficiently.

The scope of Works

i) Damage assessment

(a) The mission will assess the damage caused by the eruption to the roads, port and airport facilities, water supply, telecommunications and power sources, sanitation services and to educational and health facilities. It will also include an assessment of the status of government buildings and other key facilities in the area.

(b) The team should analyse the structural or other damage suffered by these facilities and report on the costs and viability of repairing the existing structures. This assessment should also include comment on appropriate building standards for reconstruction and whether there is a need for technical assistance for the implementation of these standards in the reconstruction, particularly with respect to building codes, materials and designs for community facilities such as schools and health centres.

(c) The mission will advise on appropriate clean-up procedures to restore essential services efficiently and with minimum delay and to improve access within the region, particularly for communities in outlying areas. The mission will also identify the priority for clean-up of different services and geographic areas, and whether there is a need for technical assistance or specialised equipment to ensure the clean-up operation is undertaken effectively and fast.

The team should liaise closely with Provincial authorities in development recommendations for the type, level and timing of the clean-up and restoration of services for Rabaul and the surrounding areas.

ii) Documentation of reconstruction requirements

(a) The mission will identify the requirements for further information on the geophysical and hydrographic status of the caldera and surrounding areas in order to provide a sound basis on which planning and reconstruction decisions can be made. This information could include data on physical features, maps, satellite imagery or aerial photography that would assist in the development of the long-term development plan for the area.

(b) The mission will prepare a rehabilitation and reconstruction program for the immediate priority works for consideration by Government and the donor community.

In the preparation of this program consideration should be given to planning for reconstruction already being undertaken by the Department of Works and other agencies. The report should identify buildings and other facilities which require urgent attention and recommend the most cost-effective way in which the reconstruction should proceed.

(c) In the preparation of this reconstruction program the team should :

(i) report on the decision-making structures and processes that have been established within the Province that will determine the organisation and management of the reconstruction program: and

(ii) identify logistical issues that will affect the implementation of reconstruction, the management and administrative requirements of the local authorities responsible for implementation and of the private sector as a key player in this process, the town-planning parameters that will affect decisions on relocation, the impact of a reconstruction program on communities and the role community groups and the private sector should play in this process.

iii) Social and Community requirements

(a) The mission will review the immediate needs of communities for assistance, particularly those in rural areas, in particular, noting the support and assistance that is currently being provided. The mission will identify any outstanding requirements for assistance to restore rural infrastructure, for example, in relation to repair of dwellings, gardens or businesses. The team should assess the need for further assessment of community needs which could be undertaken by NGOs and which may lead to the development of a program of support through NGOs.

iv) The Reconstruction Program

(a) In the light of the damage assessment above and the analysis of issues relating to relocation the team should prepare recommendations of areas for Australian and other donor assistance. Particular focus should be given to addressing priority reconstruction works and in documenting the extent of additional design that is required before reconstruction can begin.

(b) In addition to recommending on infrastructure activities for donor assistance the report should also identify the need for technical assistance that would be supportive of the reconstruction efforts, particularly in the implementation phase as planning decisions are made and building works commence. The team should also consider whether assistance is required for the preparation of contingency plans for any future disasters, eg. mudslides.

(c) The mission should recommend any immediate needs for equipment or supplies to supplement the efforts of Provincial authorities or private sector operators in the ongoing reconstruction efforts. This could include heavy equipment for cleaning or rebuilding operations, hospital equipment, school textbooks etc

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(c) The mission should recommend any immediate needs for equipment or supplies to supplement the efforts of Provincial authorities or private sector operators in the ongoing reconstruction efforts. This could include heavy equipment for cleaning or rebuilding operations, hospital equipment, school textbooks etc

In the development of the reconstruction program the team should include consideration of proposals for the redevelopment of the Kokopo urban area as outlined in the Urban Development Plan Terms of Reference prepared by the ENB Government. It should also address other issues that may affect the preparation of a regional plan for this area.

3. TEAM COMPOSITION AND TIMING OF THE MISSION

The mission should be a joint PNG- Australia effort and include officers nominated by the relevant PNG agencies at the national and provincial levels. Australian members of the team will include:

i) a structural engineering specialist, with specific experience in the rapid assessment of the condition of both large infrastructure facilities and of service networks. The engineer would have primary responsibility for the damage assessment and identification of the reconstruction requirements of infrastructure in the area and will also be responsible for the development of the reconstruction program and for developing recommendations for Australian and other possible donor support for this program.

ii) a regional planning specialist, with expertise in post-disaster reconstruction planning. The planner would be responsible for the analysis of the proposals for development of the Rabaul-Kokopo area and for assessing the appropriate strategies to address the needs for relocation and reconstruction of key infrastructure facilities. He/She would also be responsible for providing comment on the social impact of the disaster and for reviewing support being provided for rural communities.

III) an AIDAB engineering adviser who together with a nominated PNG counterpart will lead and assist the team in the field, particularly in the development of a priority reconstruction program and packages for possible donor assistance.

The team will be assisted as necessary by AIDAB officers from the High Commission in Port Moresby.

Subject to the approval of the relevant national and provincial authorities, other donor participation in the mission is welcome. Where particular technical skills or expertise can be made available by other donors (eg. relating to damage assessment or reconstruction planning for particular categories of facilities such as health, education and public utilities) responsibility for part of the mission's scope of works could be devolved in the field to other donor representatives. This should be done under the direction of the AIDAB and PNG team leaders.

It is proposed the mission be conducted for two weeks, beginning on, or as soon as possible after, the 17 October, 1994. An initial briefing will be held in Port Moresby before the team travels to East New Britain.

4. REPORTING AND CONSULTATION REQUIREMENTS

A draft report will be prepared at the conclusion of the field work period and the findings presented to the Provincial and national authorities and AIDAB and other interested donor representatives before the team departs from PNG. The draft report to be left with the PNG Government will essentially contain the damage assessment report and the reconstruction program. The report should be prepared using AIDAB CPOG guidelines for feasibility studies as a guide.

The AIDAB team will work closely with representatives of the East New Britain Provincial Government and with PNG officials from the key technical operational agencies in the Province, such as Lands, Health, Education, Works, PTC, Elcom, and the Waterboard. It is anticipated that there will be a Provincial Steering Committee formed to coordinate the exercise and the team should regularly report to this Committee during the field work period. The draft report should be presented to the Steering Committee for consideration at the conclusion of the in-country exercise.

The Team should also maintain close consultation with the consultants undertaking the Kokopo Urban Development Plan in order to ensure consistency and compatibility of data.

A debriefing on the mission outcomes will be provided to AIDAB on completion of the field mission and a final report will be prepared by the team within five days of receipt of comments on the draft report from PNG and AIDAB.

APPENDIX 2

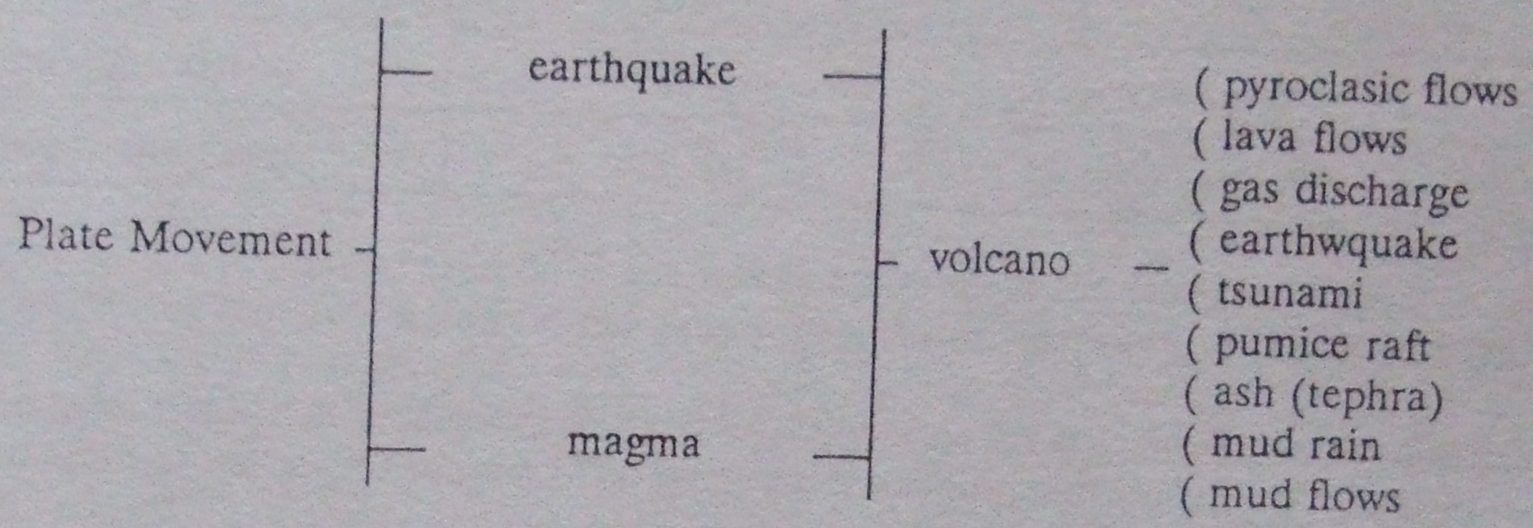
VOLCANIC HAZARDS AND RISKS

VOLCANIC HAZARDS AND RISKS

Volcanoes are commonly associated with earthquakes. Magma formation and earthquakes are in turn the product of the massive forces at work when plates of the earth's crust collide. Subduction is when such a collision leads to one plate being driven under another which is in its patch.

The effects or hazards of volcanoes take various forms all of which can be highly destructive. Some hazards occur early in the eruptive event and are highly destructive but of limited time duration (pyroclastic surveys, gas discharges, tsunamis) - other hazards may continue over long periods and may affect large areas but with less destructive intensity(ash fall, mud rain and pumice rafts).

The causes and effects of volcanoes are depicted schematically follows:



The source of the Rabaul eruptions lies in the subduction of the Solomon Plate as it moves northwards and under the Bismarck Plate (moving south) and Pacific Plate (moving north west). These plates overlap: with the contact zone between them lying further beneath the earth's surface the further north one goes. At Rabaul the contact zone is some 120 km beneath the surface.

The Rabaul area is one of the most volcanically active areas in the world. It lies at the eastern end of the Bismarck Volcanic Arc which extends for some 1 100 kms along the north coast of PNG and through New Britain to Rabaul. Among the more notable of the recently active volcanoes in the arc are Manam, Karkar, Ulawun and Long Island.

The very high level of volcanic hazard in the Rabaul area has been underscored in a number of recent studies:

- The Rabaul volcano was ranked as having the highest hazard level out of the 14 active and 20 dormant volcanoes in PNG.

- An international study of the eruptive potential of volcanic caldera in the top 3 in the world along with calderas in Italy and the USA.

The formation of Rabaul volcano began some 500 000 years ago. Since then there have been at least 10 major eruptions each of which reluctant in a collapse of the volcano to form a caldera. The most recent of the major eruptions, some 1 400 years ago, caused the development of the caldera that now forms rabaul harbour. Devastation extended over a large area of the Gazelle Peninsula, up to 50 km from Rabaul.

Rabaul volcano comprises several overlapping collapsed caldera, three large cones outside the caldera rim (North Daughter, Mother, South Daughter) and several eruptive centres within the caldera, notably Tavurvuna and Vulcan. The sea entered to form the several bays which along with the vents of Mother, North Daughter, South Daughter, Vulcan and Tavurvur form the most notable feature of the caldera complex.

The size of volcanic eruption can be measured according to the amount of material ejected. The following table shows eruption volumes and frequency of the more recent larger and smaller eruptions in the Rabaul caldera complex.

PROBABILITY OF SMALL/MODERATE AND MODERATE/LARGE ERUPTIONS TAKING PLACE AT RABAUL

Eruption	Ejected Material (cu km)	Eruption Frequency	Probability
Small/Moderate	<0.3	1 in 43 years*	96%
Moderate/Large	>10	1 in 1167 years **	4%

* Frequency based on five eruptive episodes in the last 216 years.
** Frequency based on five major, prehistoric eruptions in the last 18 000 years.

The most significant precursors or early warning signs for volcanoes are seismic (earthquake) activity and uplift of the earth's surface. The likely early warning signs for the eruption would include regional tumescence.

Vulcanologists at the Rabaul Observatory have drawn attention to the possibility that there are two substantial reservoirs of magma lying at shallow levels below Rabaul and they have indicated a set of conditions under which these could feed into a major eruption.

The six eruptions which have occurred in historic times have allowed a small but growing body of information to be assembled about patterns of seismicity, warning signs or precursors and the hazards and risks associated with small/medium sized eruptions. The timing of these eruptions (and two earlier poorly documented events) is as follows:

TIMING OF HISTORIC MEDIUM SIZE ERUPTIONS

Date	Source	Interval (yrs)
1767	Unknown	Unknown
1791	Tavurvur	24 years
1850 approx	Sulphur Creek	59 years
1878	Vulcan & Tavurvur	29 years
1937 - 1943	Vulcan & Tavurvur	59 years
1994	Vulcan & Tavurvur	51 years

Some common features of the last three eruptions are:

- all three involved the simultaneous eruption of Tavurvur and Vulcan

- swarms of intense seismic activity occurred in the day or so before the eruption
- deformations in the form of uplift occurred in the area between two vents prior to the eruptions
- each of the eruptions involved one of the vents erupting intensely for a short period of time and the other erupting less intensely over a longer period of time
- the principal hazards involved in each event were ash falls and pyroclastic surges. Hazards in the form of mud rain, lightning strikes, tsunamis, lava flows, earthquakes and pumice rafts were also present.

The difference between the three events lies in the impact of the principal hazards.

- the 1878 eruption involved no loss of life and little damage to property. It occurred in the north-west-wind season and ash from Tavurvur was blown out to sea
- the 1937 eruption caused more than 500 deaths when pyroclastic surges from Vulcan hit villages close by. It occurred in the SE wind season and there was light to moderate ash fall over the town of Rabaul
- the current eruption has caused four deaths and major damage to property with heavy falls of ash from Tavurvur over the town of Rabaul and from Vulcan over nearby villages and areas extending to the north coast. The eruption started in September which is towards the end of the SE Trade winds which blow from April to October.

In the following sections the main hazards experienced in the three medium scale Rabaul eruptions are discussed in terms of the factors which most influence which areas are likely to suffer impacts and the levels of those impacts.

Ash Falls: Critical factors are the vent location, strength of eruption (and so the amount of material and the hight of the eruption), direction and strength of prevailing winds (at different altitudes), and the size and density of particles. Rabaul township lies some 7 kms directly downwind of Tavurvur in the SE Trade winds seasons.

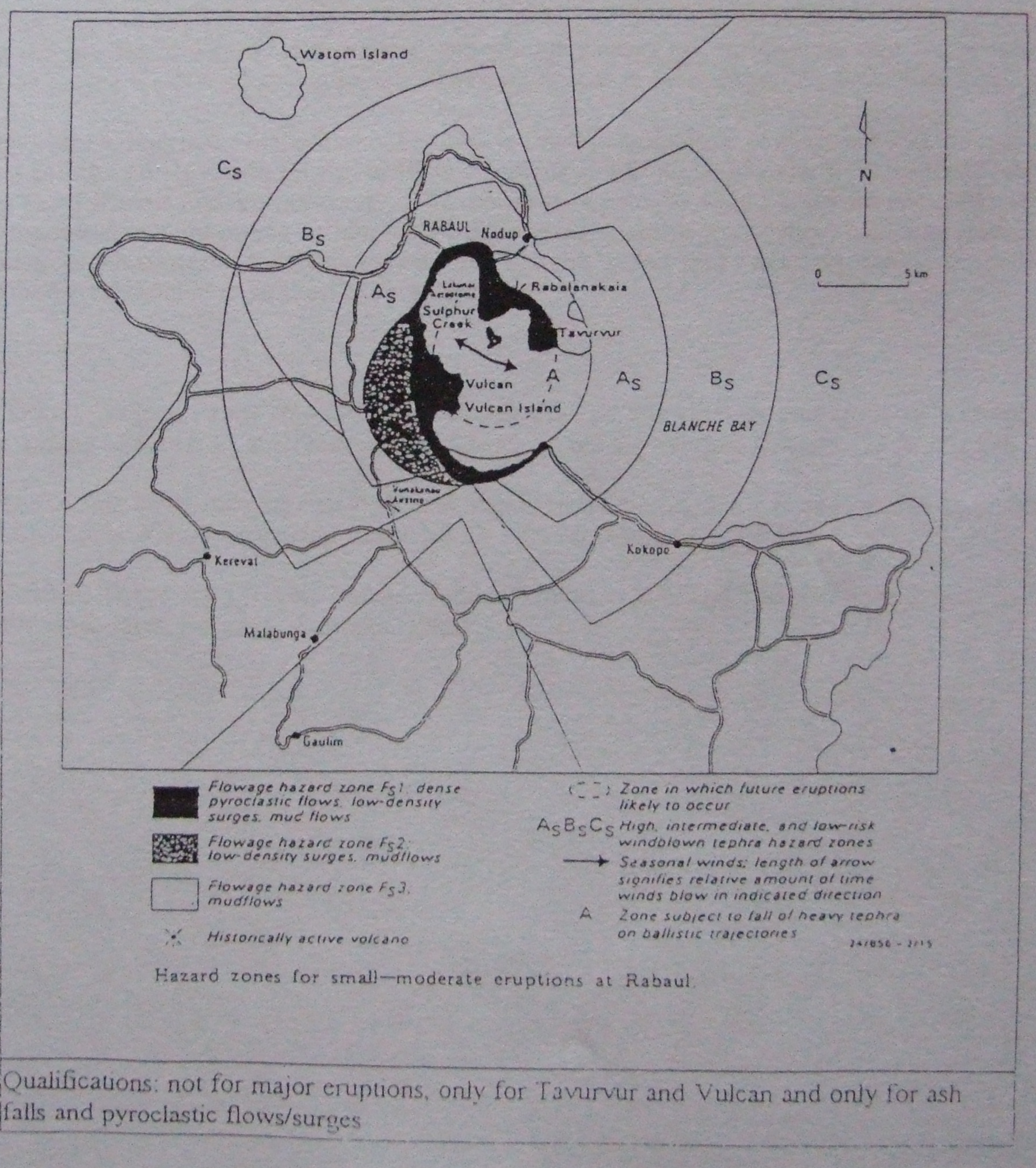
Pyroclastic Surges: These involve flow of hot gas, ash and rock fragments down the slopes of the volcano and across adjacent land seascape. They often occur early in the eruption. Pyroclastic surges have been part of the Vulcan eruptions - with disastrous consequences in terms of loss of life in 1937 and devastation to nearby villages in 1994. Surges may have formed part of the Tavurvur eruptions but have not been linked to any loss of life or property. It seems that the caldera rim might contain surges occurring as part of medium strength eruptions but would be unlikely to contain the kinds of surges which would occur with major eruptions.

Tsunamis: Tsunamis or tidal waves are most commonly caused by earthquakes. They may also be caused by submarine earthquakes, pyroclastic surges which enter the sea and very large pumice or ash falls. The frequency and intensity of tsunamis depends on the magnitude of the source and the configuration and the extent of water bodies involved.

Tsunamis were experienced in the 1937 and 1994 eruptions. The 1994 tsunamis were only minor and did not cause much damage. The 1937 tsunamis extended over some five hours with wave heights up to 5 m and intervals down to 10 minutes but again no damage was recorded.

Mudflows: The critical factors are intensity of ash fall, steepness of terrain, size and definition of drainage catchments, size and properties of ash particles and volume and intensity of rainfall.

Hazard Mapping: In overall terms the factors which are most important to the mapping of hazards are the strength of an eruption and its location. A further critical factor is wind pattern. The following map represents in highly summarised form hazard mapping for ash falls and pyroclastic surges and flows for the Rabaul area.



Hazard zones for small—moderate eruptions at Rabaul.

Qualifications: not for major eruptions, only for Tavurvur and Vulcan and only for ash falls and pyroclastic flows/surges

It can be seen that:

- Rabaul falls within the zone with the highest level of hazard for flowage effects including pyroclastic flows surges and mud flows. It also falls wholly with the zone with the highest level of hazard for ash falls (windblown tephra)

- both Kokopo and Kervat fall outside the lowest zoning for flowage hazard

- Kokopo falls in the intermediate zone for level of ash fall hazard while Kerevat lies in the low risk zoning for ash fall hazard

The evacuation plan for Rabaul provides for evacuation of areas according to the time of year, ie according to prevailing wind conditions. Northern areas are to be evacuated for eruptions occurring during the SE Trade wind period: eastern and southern areas are to be evacuated for eruptions occurring during the NW Monsoon period. The core area is to be excavated in both situations.

It is important to realise the limitations of Figure 6, in relation to the scale of eruptions and the location of vents considered. It relates only to medium eruptions, not to major eruptions. Secondly it relates only to the Tavurvur and Vulcan vents. Different hazard patterns would apply for the other vents within the caldera and of course nothing can be done to map hazards from vents which may emerge in the future. In this context it should be remembered that the Vulcan vent was largely submarine in 1878 but formed a subairial cone in the 1937 eruption.

REFERENCES

1. Rabaul Caldera, Papua New Guinea : volcanic hazards, surveillance, and eruption contingency planning McKee C.O. et al, Journal of Vulcanology and Geothermal research, 23 (1985) 195-237.

2. The impact of volcanic hazards at Rabaul, Papua New Guinea, Glong R and Aisabie C, Institute of National Affairs Discussion Paper No 33, Port Moresby, April 1988.

3. Volcano Town: the 137-1943 Rabaul eruptions, Johnson R W and Threlfall N A, Robert Brown and Associates, Buranda, Australia, 1985.

APPENDIX 3

DETAILS OF PROPOSAL PROJECTS

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
R1	Kavavar Kurakakaul Rd Upgrade and Sealing including repairs and drainage works on the North Coast Road		To provide an alternative all weather access between Rabaul and Kokopo/Vunadadidir	1 Design and document works 2 Construct 7.6 km of K/K Rd and carry out repairs and drainage works on the North Coast Road	Immediate	DOW		K1.5m Medium
R2	Emergency Maintenance on Reimber Community Roads		To reinstate the roads to their pre-eruption condition.	1 Resheet and maintain Vunalaka/Kurakakaul Road 2 Resheet and maintain Ramale/Vunavutung Road 3 Resheet and maintain Iatapal/Vunalir Road 4 Emergency maintenance to minor roads	Immediate	DOW		K2.6m Medium
R3	Rabaul Town Access		Maintain limited access to Rabaul town generally and good access to the light industrial area.	1 Ash removal a required 2 Berm construction to protect valuable assets.	Immediate	DOW		K0.5m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
R4	Rabaul Town Road Rehabilitation		To rehabilitate the road and stormwater drainage system in Rabaul Town and Nodup	1 Remove ash 2 Clean out drains 3 Repair damaged pavement and seal.	Start at the end of the wet season	DOW		K7m
R5	Kokopo Rd & Burma Rd rehabilitation		To reconstruct Kokopo & Burma Rds where they are damaged by the eruption	1 Design and document 2 Construct	Start at the end of the wet season	DOW		K2.5m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
A5	Navigation aids for Tokua airport	Either	To improve safety by installing modern navigation aids	1. Determine precise requirements 2. Procure and install -Visual landing aids such as T/vasis - Landing lights - Beacon lights - other requirements	Dec 94-Mar 95	DCA	A1, A2, A3	K1.00m
A6	Weather monitoring equipment for Tokua airport		To improve safety by installing modern satellite-linked weather monitoring equipment	1. Determine requirements 2. Procure and install equipment	Jan 95-May 95	DCA		K1.00m
A7	Radio equipment for Tokua airport		To improve safety by providing modern communications equipment	1. Determine requirements 2. Procure and install equipment	Jan 95-May 95	DCA		K0.60m
A8	Staff housing at Tokua airport		To provide houses for DCA staff at Tokua airport	1. Determine requirements 2. Design 3. Construct 4. Dispose of houses in Rabaul	Nov 94-Nov 95	DCA	A2, A3, A4	K4.00m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
A9	Maintentenance and stores buildings at Tokua airport		To provide shelter and security for maintenance equipment , tools, stores and staff	1. Determine requirements 2. Design 3. Construct	Nov 94-May 95	DCA		K0.50m
A10	Control tower for Tokua airport		To provide a control tower and necessary equipment to control air traffic movements safely and efficiently	1. Design 2. Construct 3. Furnish and install equipment	Nov 94-May 95	DCA	A2, A3, A5, A6, A7	K0.50m
A11	Administration building at Tokua airport		To provide offices and equipment for DCA staff	1. Design 2. Construct 3. Fit and furnish	Nov 94-May 95	DCA	A2, A3, A4	

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
W1	Generators for bores at Rabaul and Nonga	Prioritise generators for Rabaul according to level of relocation	To provide generators to run pumps on bores at Rabaul and Nonga until mains power is restored and then to act as standby units	1. Procure and install 5 generators	Nov 94	WB		K0.80m
W2	Repairs to water mains and services	Priorise work in Rabaul according to level of relocation	To locate and repair leaks in the reticulation system	1. Procure backhoe and attachments 2. Provide pipes and fittings	Nov 94 ongoing	WB	W6	K0.15m
W3	Water Board office and equipment	Medium Level	To provide an office and necessary equipment for Water Board staff	1. Determine requirements 2. Design 3. Construct 4. Furnish and equip	Dec 94-June 95	WB		K0.30m
W4	Water Board stores and workshop	Either - Preferably at Kokopo	To provide shelter and security for stores, tools, equipment and staff for both water reticulation and sewerage purposes	1. Determine requirements 2. Design 3. Construct 4. Provide tools and equipment as required	Dec 94-June 95	WB		K0.30m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
W5	Water Board housing	Medium level	To provide housing for Water Board staff	1. Determine requirements 2. Design 3. Construct 4. Repair repairable Water Board houses	Nov 94-Nov 95	WB		

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
W6	Clean and repairs to Rabaul sewerage system	Abort with medium level relocation	To clean, repair and bring back into service all components of the seweage system	1. Clear outfall 2. Clean out Imhoff tank 3. Test and repair sewer lines 4. Dig out, check and reinstall pumps and protect them (with sandbags) against further mud flows 5. Disconnect and seal property services until they are required	Dec 94-June 95	WB	W2	K0.20m
W7	Rural water supplies		To provide water in the short and medium term to displaced people in outlying villages	1. Bores 2. Pumps 3. Reticulation	Immediate start	WB		K1.20m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
EL1	Repair transmission lines	Either	To bring back into service the 66kV line south of Rabaul and secure the 22kV line on the north coast	1. Replace or straighten fallen or leaning poles	Nov-Dec 94	ELCOM	EL2	K0.70m
EL2	Repair distribution lines	Prioritise according to level of relocation	To restore electricity to Rabaul and nearby areas	1. Repair or straighten fallen or leaning poles 2. Disconnect all private services until inspection and certification has been carried out	Nov 94-Feb 95	ELCOM	EL1	K0.20m
EL3	Remove ash from ELCOM's assets	Either	To remove corrosive ash from cables, insulators and generators	1. Seek expert advice on best method of removing the ash 2. Procure or hire equipment necessary to remove the ash 3. Implement ash removal programme	Dec 94-Mar 95	ELCOM		K1.50m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
EL4	Repair ELCOM office	Medium level	To restore ELCOM's office in Rabaul	1. Design new roof 2. Construct new roof 3. Undertake major clean up and renovations 4. Replace damaged furniture and equipment	Dec 94-May 95			K0.30m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
EL5	New ELCOM store and workshop	Either- Preferably at Kokopo	To provide secure storage and ample work room for ELCOM's staff.	1. Determine requirements 2. Design 3. Construct 4. Supply equipment	Dec 94- June 95	ELCOM		K0.40m
EL6	ELCOM housing	Medium level	To provide housing for ELCOM's staff	1. Determine requirements 2. Design 3. Construct 4. Renovate repairable ELCOM houses	Nov 94- Nov 95	ELCOM		K2.50m
EL7	Consolidate diesel generators at Kokopo	Either	To coinsolidate Rabaul and Kerevat generators at Kerevat	1. Feasibility study 2. Design 3. Dismantle, transport and reassemble generators 4.Modify transmission and distribution lines as necessary		ELCOM		K3.00m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
T1	Rabaul exchange and business office	Low level	To relocate the Rabaul exchange	1. Research alternative locations 2. Design 3. Construct 4. Procure equipment 5. Install equipment	Dec 94-Sep 95	PTC	T2	K3.50m
T2	Electricity for new exchange	Low level	To provide electricity to the new exchange	1. Design 2. Construct	Apr 95	PTC, ELCOM	T1	K0.10m
T3	Water for new exchange	Low level	To provide water to the new exchange		Apr 95	PTC, WB	T1	K0.05m
T4	New Telikom stores and workshops	Low level	To provide secure storage and ample work room for materials and staff	1. Determine needs 2. Design 3. Construct 4. Procure tools and equipment	Dec 94-June 95	PTC		K0.80m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
T5	New transmitter building in Rabaul	Low level	To build and equip a new transmitter building	1. Demolish old building 2. Design new building 3. Construction 4. Procure and install radio equipment 5. Procure or hire cleaning equipment 5. Clean ash from masts and cables				K1.20m
T6	Underground cables	Prioritise this work in Rabaul according to level of relocation chosen	To test, and replace where necessary, underground cables	1. Dig up pits 2. Test cables 3. Replace damaged cables 4. Investigate various options if cables are badly damaged eg radio links, fibre optic cables	Dec 95-ongoing	PTC		K3.00m

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
T7	PTC housing	Low level (utilise existing undamaged in Rabaul)	To provide housing for PTC staff	1. Determine requirements 2. Design 3. Construct 4. Renovate repairable PTC houses	Nov 94-Nov95	PTC		K2.00m
P1	New Post Office	Sizing of Post Office function of level of relocation	To replace the Rabaul Post Office	1. Design (after carefully analysing causes of the catastrophic failure of this near new building) 2. Construct 3. Furnish and equip	Dec 94-Sep 95	PTC		
RA1	New NBC studio	Low level	To replace the NBC studio which was destroyed	1.Find a safer location 2.Design 3. Construct 4. Procure equipment 5. Install equipment	Dec 94-Sep 95	NBC		

No	Project name	Relocation Options	Objective	Components	Timing	PNG agencies	Related projects	Indicative Cost & FX comp'nt
RA2	Reroof building at Kuakakaul transmitter	Either	To reroof the rapidly corroding roof on the building at the Kuakakaul transmitter to protect the valuable and sensitive equipment inside it	1. Replace roof	Not urgent, but condition must be closely monitored	NBC		K0.05m
RA3	Complete project - radio link to North Solomons	Low level	To complete the erection of the antenna and install the equipment for the North Solomons radio link	1. Determine satisfactory method of removing corrosive ash from project components 2. Carry out cleaning 3. Complete project including installation of antenna and other equipment	Immediate	Telstra		-
RA4	NBC staff housing	Low level	To provide housing for NBC staff	1. Determine requirements 2. Design 3. Construct 4. Renovate repairable houses	Nov 94-Nov 95	NBC		K0.60m

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
E1	Community School Temporary Building Facilities	Either, with priority to Kokopo	To provide temporary facilities at Community Schools for the start of the 1995 academic year.	1 Determine the anticipated demand for community school education for the 1995 academic year. 2 Design and document the temporary facilities to meet the demand in each location. 3 Construct the temporary facilities.	Complete by Febuary 1995	DivE DOW		K1.0m low
E2	Community School Permanent Buildings	Medium level	To provide permanent building facilities at Community Schools to suit demand.	1 Determine the anticipated long term demand for primary education by location 2 Design and document the facilities 3 Construct the facilities	Begin after ash and flood hazard is low	DivE DOW		K2.0m Low

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
E3	Provincial High School Temporary Facilities	Medium level	To provide temporary facilities at Provincial HS for the start of the 1995 academic year.	1 Determine the anticipated demand for Provincial High Schools education for the 1995 academic year. 2 Design and document the temporary facilities to meet the demand in each location. 3 Construct the temporary facilities.	Complete by Febuary 1995	DivE DOW		K0.80m
E4	Provincial HS Permanent Buildings	Medium level	To provide permanent building facilities at Provincial HS to suit demand.	1 Determine the anticipated long term demand for Prov HS education by location 2 Design and document the facilities 3 Construct the facilities	Begin after ash and flood hazard is low	DivE DOW		K1.4m Low

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
E5	Displaced primary student education	Either (consider bussing to Kokopo)	To provide temporary facilities for primary education at settlement sites for the start of the 1995 academic year.	1 Determine the anticipated demand for primary education at settlement sites for the 1995 academic year. 2 Design and document the temporary facilities to meet the demand in each location. 3 Construct the temporary facilities.	Complete by Febuary 1995	DivE DOW		K1.80m Low
E6	Education Materials and office equipment	Either	To provide education materials for Provincial HS and Community Schools in 1995	1 Procure materials 2 Procure equipment	Complete by Febuary 1995	DivE		K1.00m medium

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
E7	Rabaul Tech HS Reconstruction	Medium level	To open the Rabaul Tech HS to classes in 1995 and ultimately provide facilities equal to pre-eruption.	1 Design and document the repair and upgrading works 2 Construct the new facilities and repair other buildings to permit the school to open. 3 Provide materials and equipment 4 Complete the remainder	Comp 2 Start after hazard risk is low.Complet e by Feb 1995	DeptE DOW		K1.1m low
E8	Relocate CODE office	Low level	Initially relocate Rabaul CODE office to the mainland and reconstruct a new ofice when possible	1 Relocate staff to mainland and provide new equipment and office space 2 design and document a new Rabaul office 3 Construct the new office 4 Relocate staff back to Rabaul	Comp 1 Immediate	DeptE DOW		K0.50m low

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
E9	Repair Public Library	Medium level	Reopen the public library	1 Design and document repairs 2 Construct repairs 3 Provide new books and equipment	Start after hazard risk is low.	DivE DOW		K0.65m High
E10	Tok Ples Skul	Medium level	Reopen Tok Ples Skul at the beginning of 1995 academic year.	1 Relocate offices to new premises 2 Replace damaged equipment and materials	Complete by Feb 1995	DeptE		K20,000 High
E11	Rabaul Girls Voc School	Either for components 1-3. Medium level for component 4.	Relocate students to other schools in 1995 and reconstruct the school	1 Relocate students and staff to other schools in 1995 2 Replace damaged materials 3 Replace damaged equipment 4 Reconstruct the buildings	Reallocate students by Feb 1995	DeptE DOW		K0.4m Medium

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost &Forex Comp'nt
H1	Assist Immunization Program	For action - either option	To protect high risk groups from communicable diseases.	1 Relocation of coolstore from the Area Medical Centre to Vunapope. 2 Provide medical staff	Immediate	DeptH DivH DOW		K0.3m low
H2	Vunapope and Butuwin Hospital upgrade	Medium level	To provide alternative provincial hospital facilities to Nonga Base Hospital	1Design & documentation 2 Construct at Vunapope Hosp 2.1 Mortuary 2.2 Standby Gen Set facility 2.3 Temporary Staff Housing	Immediate	DOW DivH		K0.3m Medium
H3	Nonga Base Hospital refurbishment	For action - either option	To reestablish Nonga Base Hospital as the regional referral centre.	1 Design and documentation 2 Repair damage to hospital buildings 3 Repair damage to staff houses	Begin after ash hazard is low	DOW ELCOM PTC		tbd
H4	Assist Health Education Programme	For action - either option	To increase health awareness and knowledge of health issues in the population	1 Provide Health Education materials. 2 Provide finance to facilitate trauma counselling	Immediate	DivH		K250,000

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost &Forex Comp'nt
H5	Health impact of eruption study	For action - either option	To determine long term health implications from the eruption.	1 Analyze ash composition and predict health implications from inhalation.	Immediate	DeptH		K5000
H7	Bukuwin Health Centre Upgrade	Low level	To provide alternative facilities at Bukuwin Health Centre	1 Design & Documentation 2 Construct following at Bukuwin HC 2.1 Temporary Childs Ward 2.2 Kitchen & ablution 2.3 Office to accomodate Rabaul Clinic services 2.3.1Family Planning 2.3.2Nutrition 2.3.3Disease Control 2.4 TempHead Office facilities 2.4.1 Offices 2.4.2 Temp Staff Housing	Immediate	Div H DOW		K0.33m medium
H8	Rabaul Clinic Reconstruction	Low level (re-establish Rabaul later)	To reestablish clinic to service Rabaul Town	1 Design & documentation 2 Construct new buildings	Begin after ash and flood hazard is low	DivH DOW		K0.3m

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost &Forex Comp'nt
H9	Settlement Areas Health Centres	Either	Provide infrastructure for Health Centres near resettlement areas.	1 Locate health centres 2 Design and Documentation 3 Construct one Health Centre 4 Construct Staff housing	Complete when settlers arrive.	DivH DOW		K0.32m low
H10	Regional Health Staff Repatriation	Either	To reestablish the regional health functions on the mainland.	1 Move staff and families to nominated centre on the mainland	Immediate	DeptH		K10,000
H11	Handicapped Rehabilitation Centre	Low level	Provide facilities for a rehabilitation centre for handicapped people.	1 Design and Documentation 2 Repair existing building	Begin after ash and flood hazard is low	DivH DOW		K60,000
H12	Supply of office and medical equipment	Either	Provide items destroyed during the eruption	1 Procure equipment	Immediate	DivH DeptH		K0.5m

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
L1	Tomaringa Barrack Upgrade	Either for components 2 and 3 Medium level for components 4-6.	Provide temporary facilities to accomodate functions relocated from Rabaul.	1 Design & Document 2 Partition existing classrooms to accomodate Provincial & Divisional functions. 3 Provide PABX 4 Construct watchhouse to accomodate 20 persons. 5 Construct barracks to accomodate 90 single persons 6 Construct married quartersfor 10 families	Immediate	RPNGC DOW		K2m medium
L2	Nodup Police Post	Either	Provide police post for the Nodup community whilst HQ located at Tomaringa	1 Construct post	Immediate	DOW		K0.05m
L3	Equipment & Materials	Either	Replace damaged equipment and materials for police and courts	1 Replace damaged office equipment 2 Replace damaged forensic equipment 3 Replace damaged materials from the Qmasters store	Immediate	RPNGC DOJ		K0.7m

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
L4	Reconstruct and Repair Rabaul PS	Medium level	To provide facilities for the Provincial and Divisional functions of the RPNGC	1 Design and document 2 Construct new station	Start after hazard risk is low.	DOW		K0.7m medium
L5	Reconstruct Barracks at Malaytown	Medium level	Provide permanent accomodation for police in the main urban centre	1Design and document 2 Construct 52 single and 31 married quarters, mess, kitchen, gym & Qmaster's store. 3	Start after hazard risk is low.		DOW	K4.7m medium
L6	Reconstruct and repair Courthouse	Low level	Provide permanent accomodation for District, National & Land Courts	1 Design and document 2 Construct and repair court house	Start after hazard risk is low.		DOW	K0.60m medium

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
PG1	Kuanua St complex Reconstruction	Medium level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K1.2m medium
PG2	Provincial Assembly Complex Reconstruction	Medium level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K0.7m medium
PG3	Vesters st Complex Reconstruction	Medium level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K0.45m medium
PG4	Lands and Forests Complex	Medium level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K0.90m medium
PG5	Education Complex Reconstruction (Malaguna St)	Medium level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K0.35m medium
PG6	Office equipment supply	Medium level	Provide replacement office for those damaged during the eruptions	1 Provide equipment	Immediate.	DENB		K0.55m high

No	Project Name	Relocation Options	Objective	Component	Timing	PNG Agencies	Related Projects	Indicative Cost and Forex Component
NG1	National Disaster and Emergency Centre Reconstruction	Low level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	NDES DOW		K80,000 medium
NG2	National Housing Commision Office Reconstruction	Low level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K30,000 medium
NG3	Dept of Works Vehicle Workshop and Provincial HQ damaged	Medium level	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DENB DOW		K2.6m medium
NG4	Fire Station Reconstruction	Sizing of station function of level of relocation	Provide permanent office accomodation similiar to pre-eruption levels.	1 Design & document 2 Construct and repair buildings	Start after hazard risk is low.	DOW		K0.25m medium
NG5	Office equipment supply	Either	Provide replacement office for those damaged during the eruptions	1 Provide equipment 2 DOW equipment/tools	Immediate.	DENB		K2.0m high
NG6	Volcano Monitoring equipment Supply	Either	Provide equipment to monitor the Rabaul volcanos	1 Provide equipment	Immediate.	RVO		K1.8m high

APPENDIX 4

PHOTOGRAPHS



Tavurvur 21 October 1994 - Ash falling on Rabaul and harbour



Rabaul wharf and pumice raft



Erosion problem at Malaguna
due to ash from Vulcan



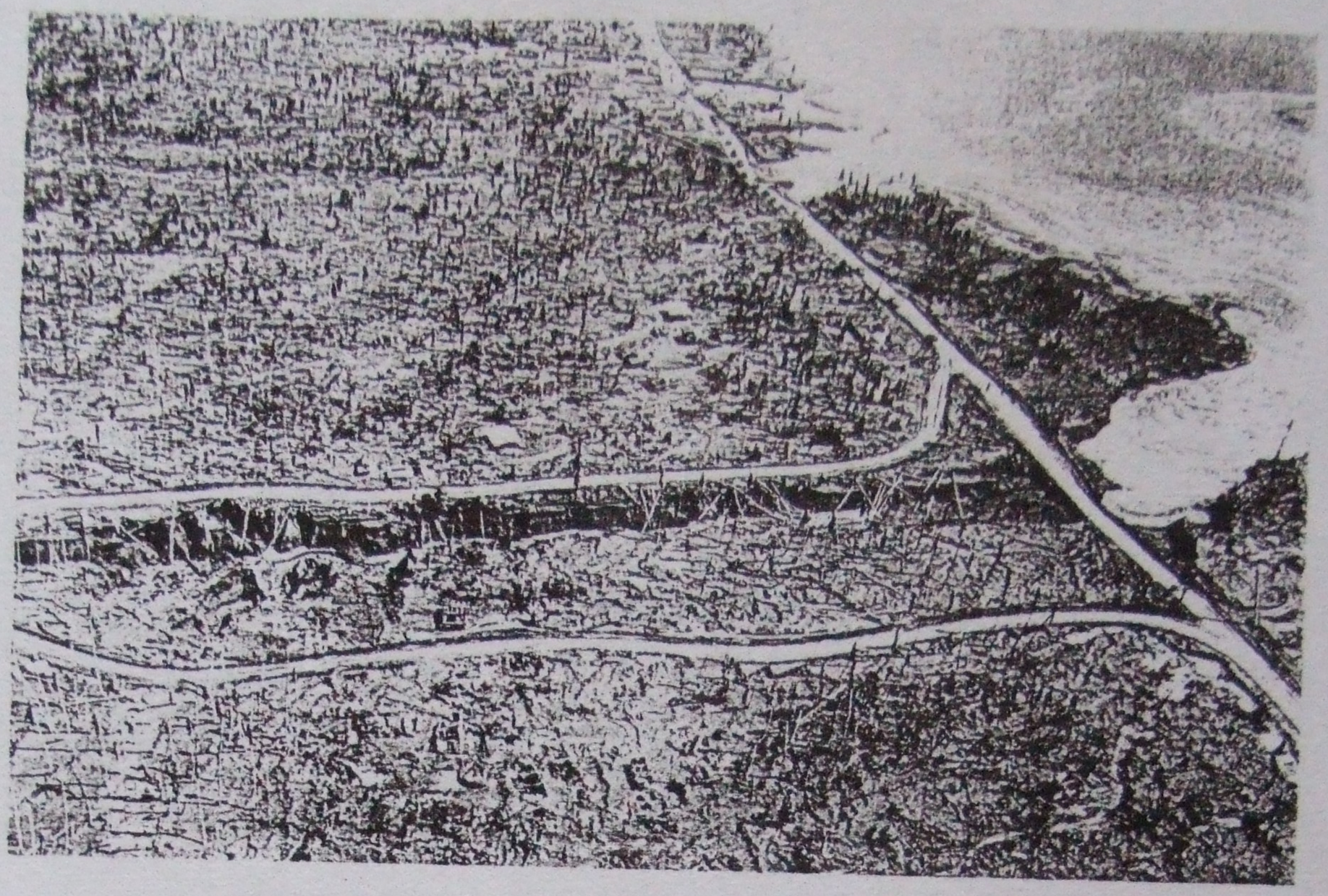
Kokopo Road at Malaguna. Trees
are flattened in the direction
of the pyroclastic surge



Mango Avenue at Namanula Road



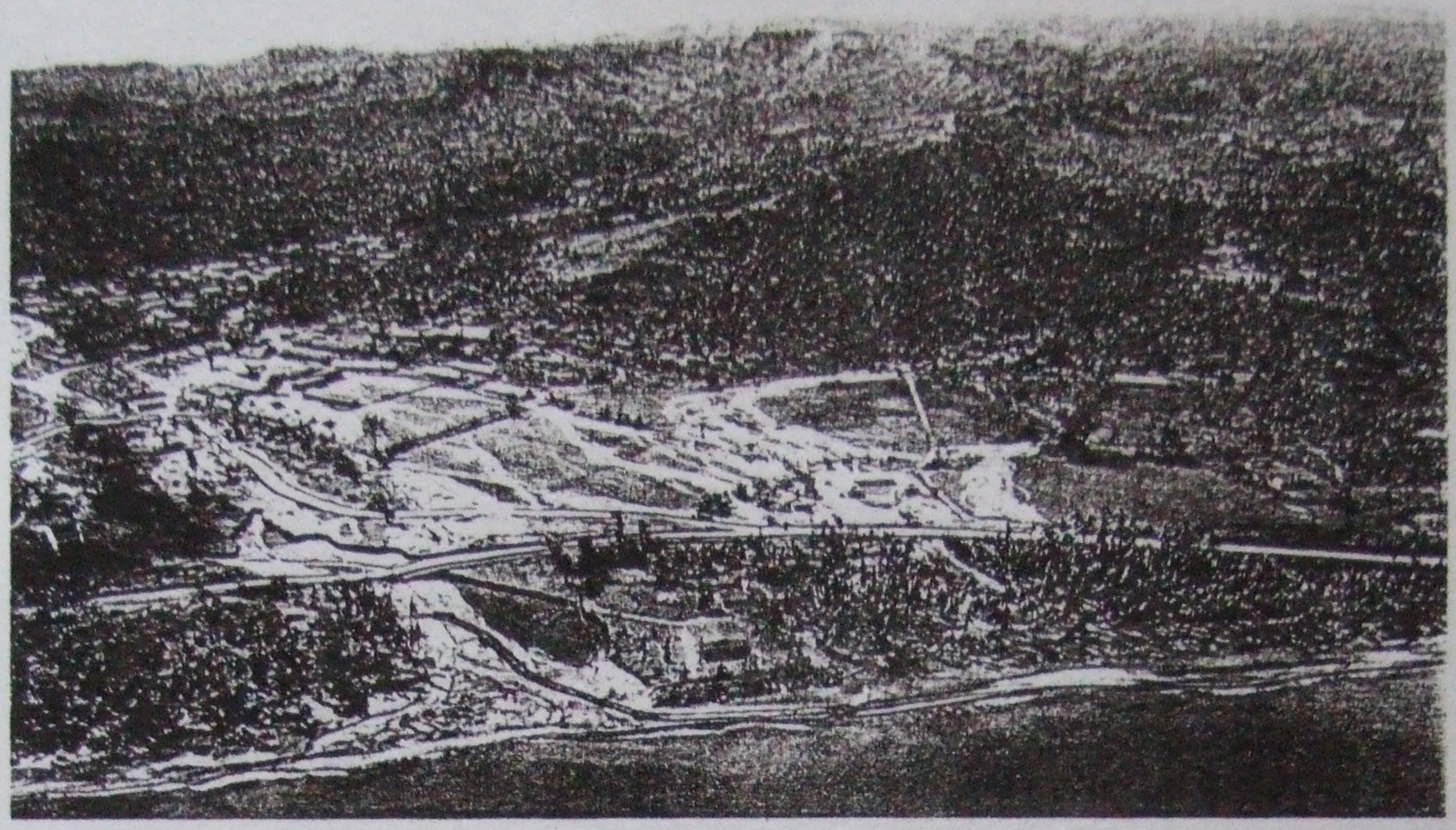
Mango Avenue. View
south near Kuanua Street



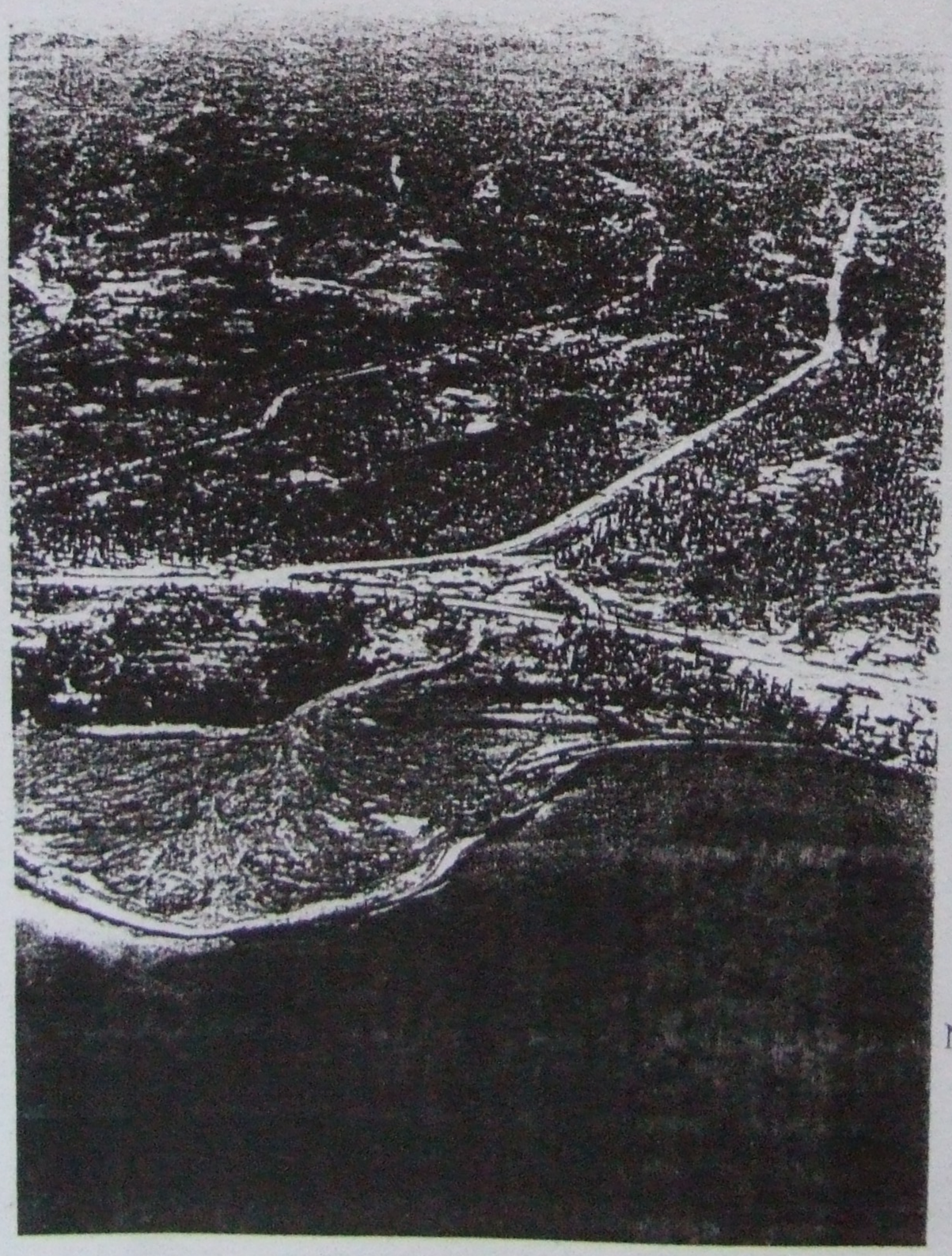
Kokopo Road/Burma Road intersection.
Note washout on Kokopo Road



Kokopo Road adjacent to Vulcan



North Coast Road at Vuvu. Note damage to road by flooding. St Mary's High School is in the left of the picture



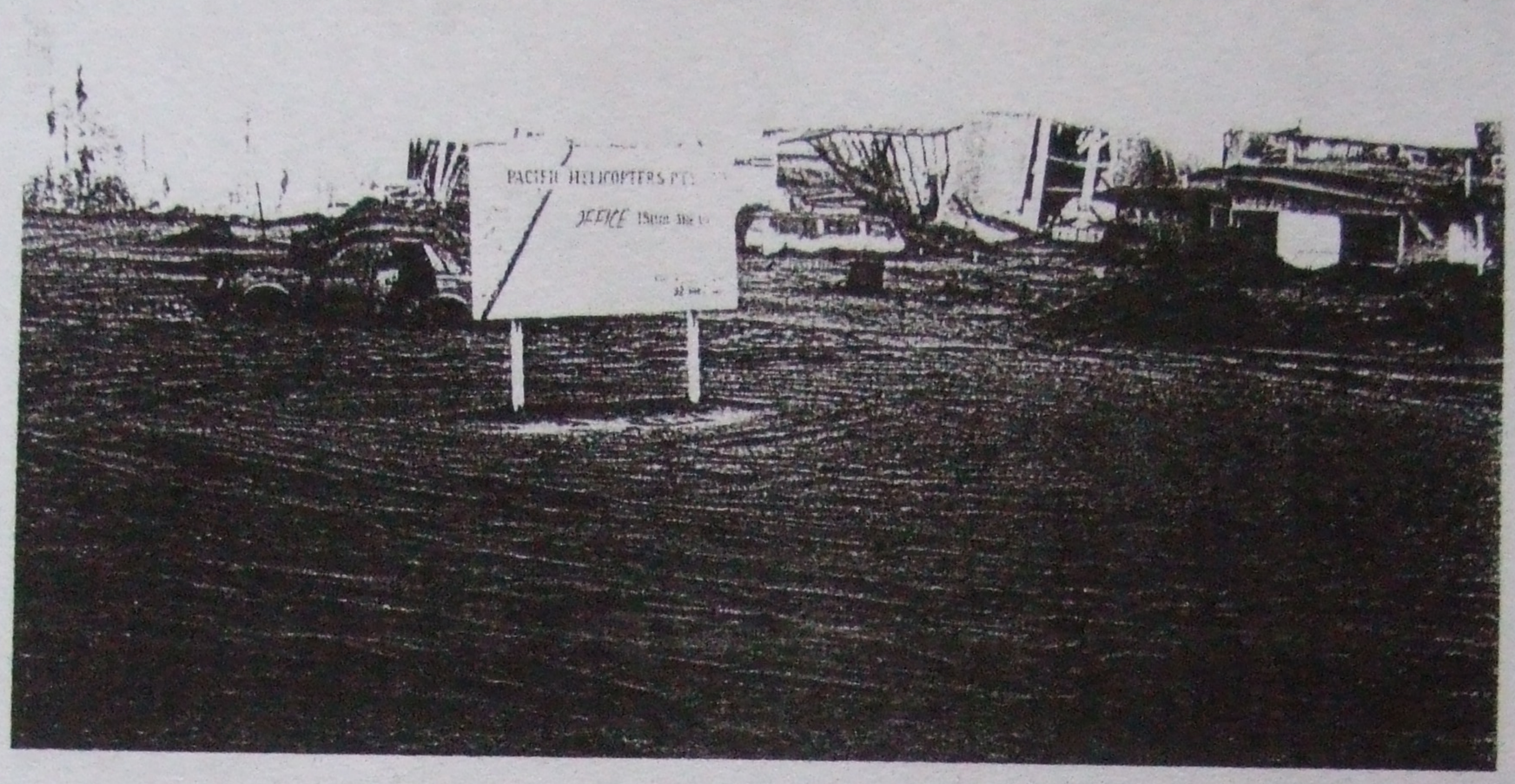
North Coast Road at Kurakakaul. Note delta formed by recent flooding.



East end of Malaguna Road in Rabaul



Rabaul airport



Rabaul airport. Terminal building in background



Rabaul airport. DCA Administration building



Tokua airport. Air traffic control



Tokua airport. Office cum sleeping quarters



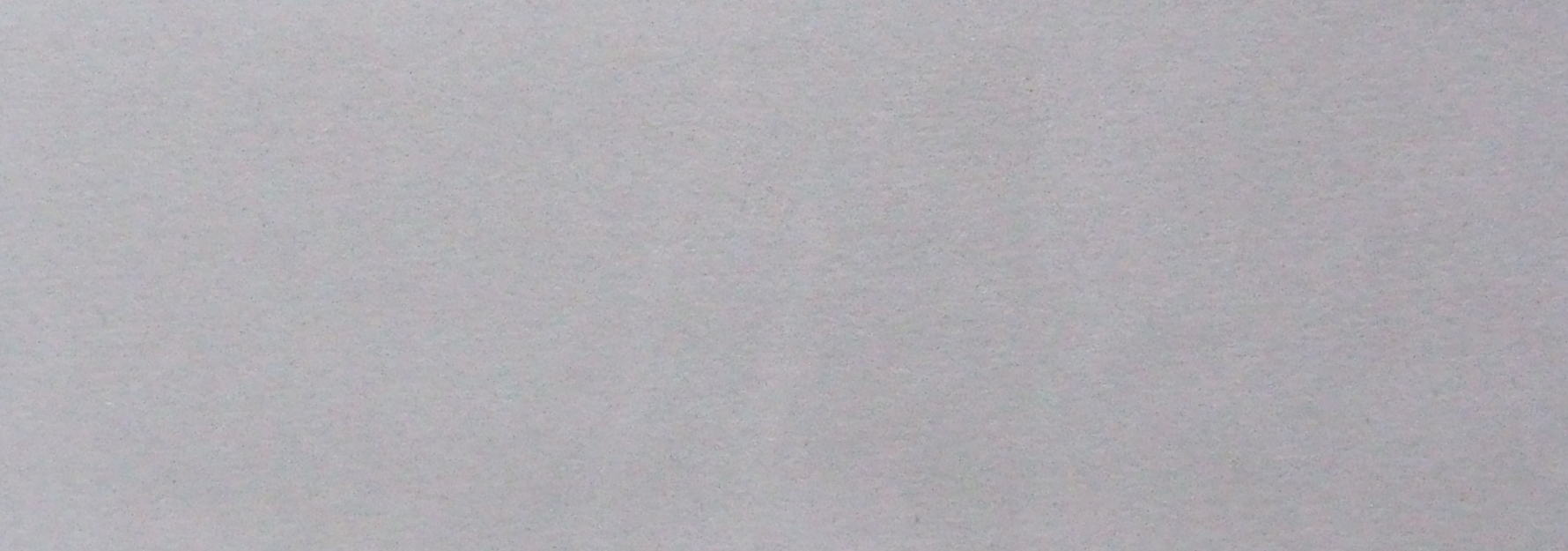
Water Board storeshed - Vesters Street



Water Board house - Vesters Street



Water Board bore near Rabaul High School. Ash depth is about 1.5 m



Water Board Imhoff tank where sewage is treated.
It requires cleaning out.



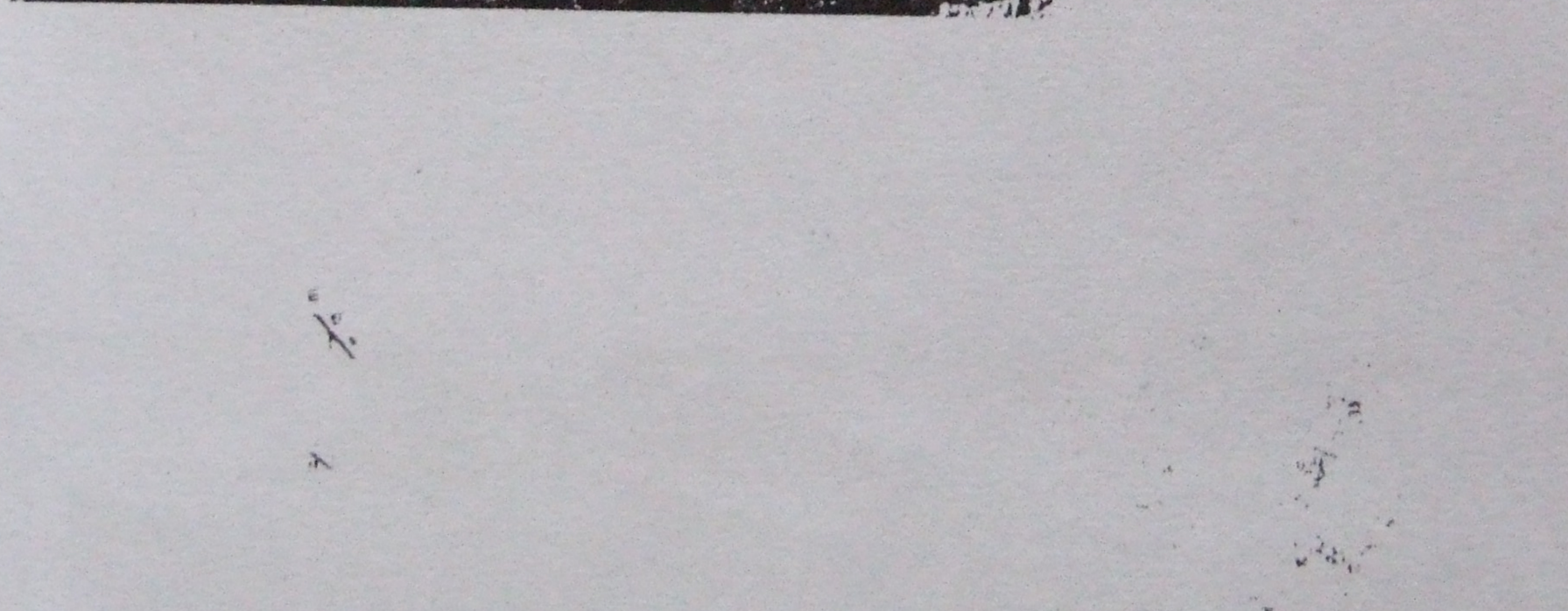
Access road to Tokua airport. Upgrading in process.



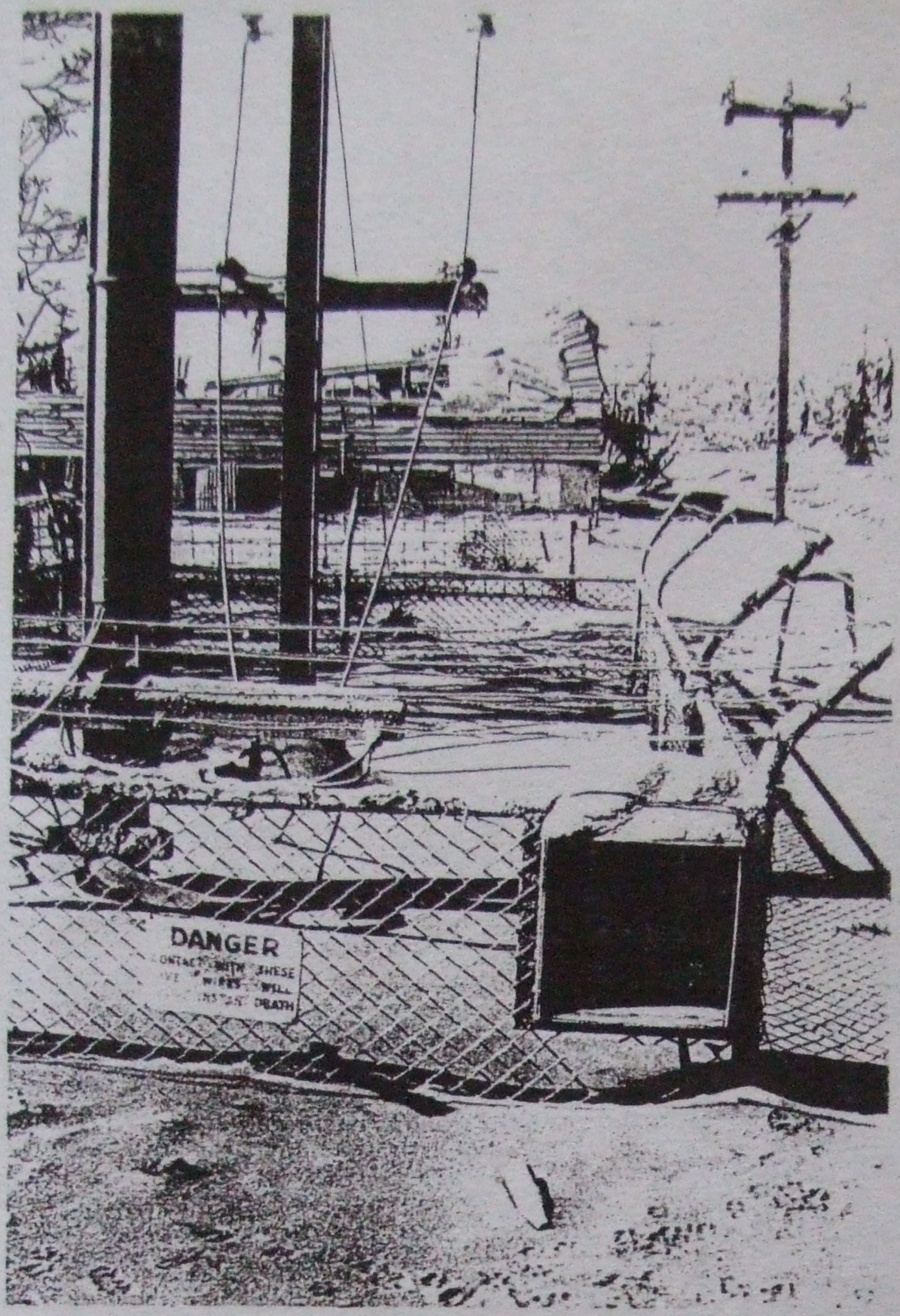
66 KV line in Burma Road. Flooding has eroded around poles and stays causing the poles to lean.



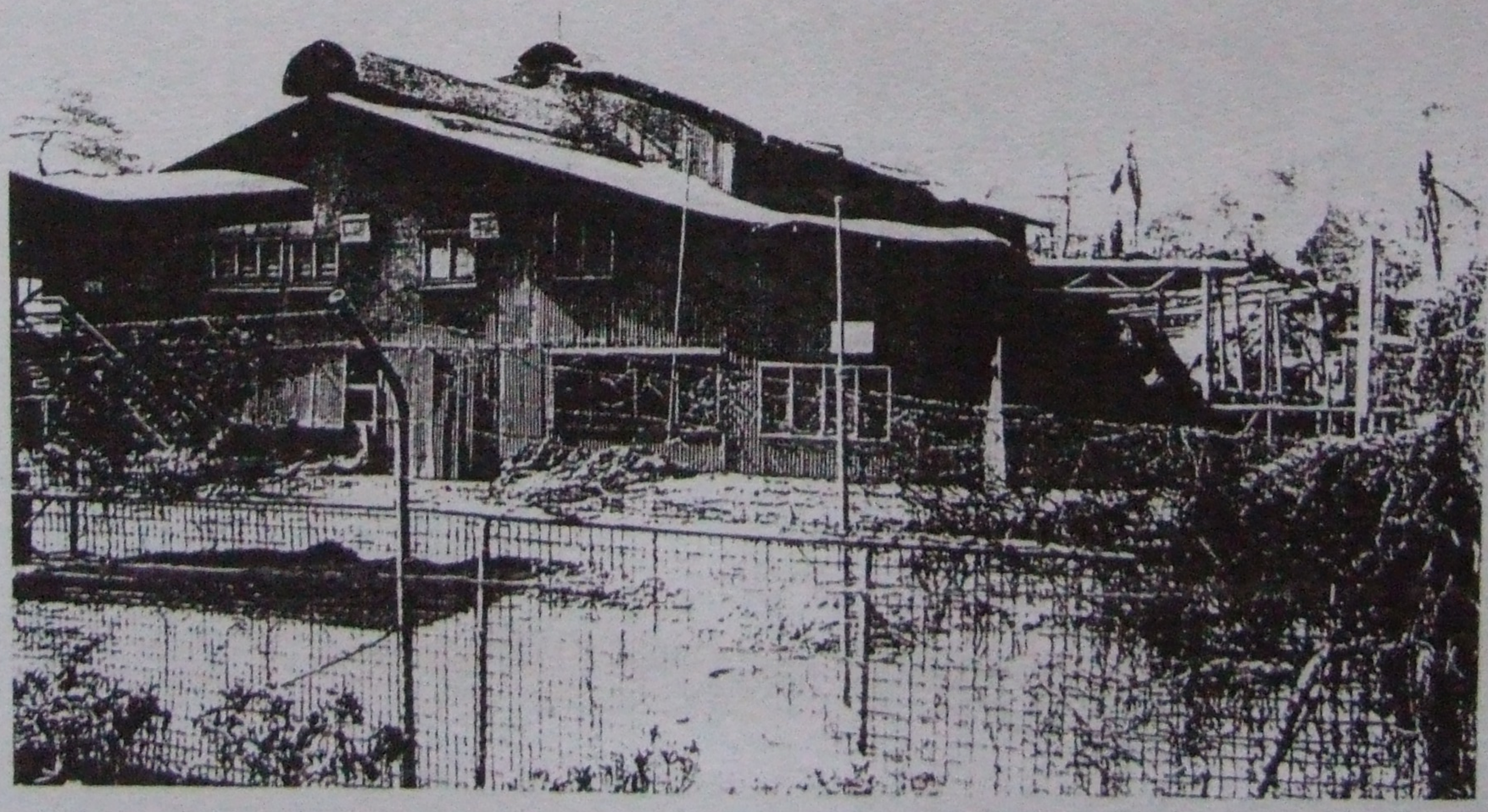
66 KV line in Kokopo Road. Pole has fallen over due to flooding. Its top is visible in the right of the picture.



22 KV line on North Coast Road. Pole and stay have dropped more than 2 metres due to erosion



Substation in Vulcan Street.
Note depth of ash, about 2 metres.
The transformer is buried.



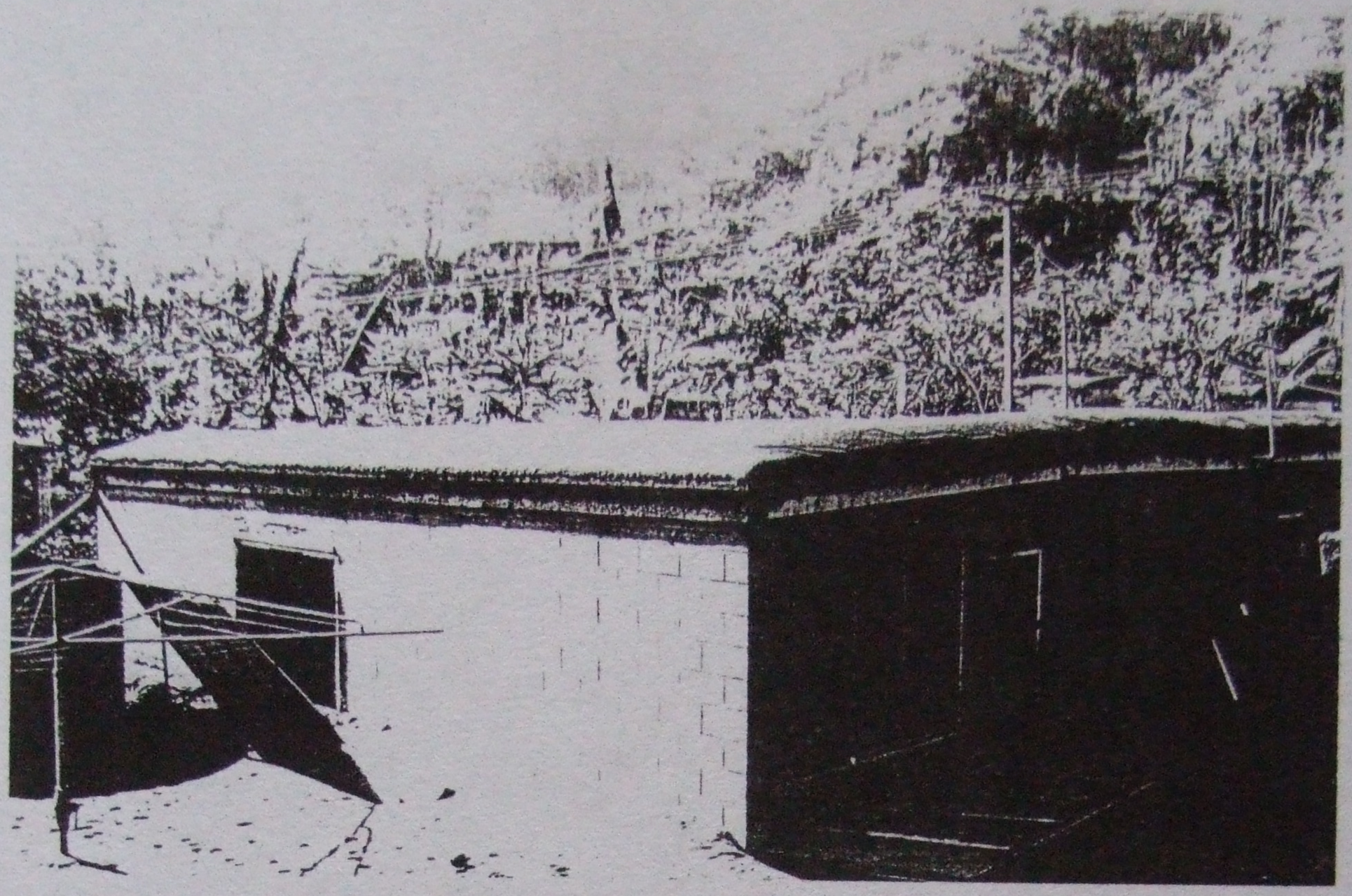
Elcom storeshed in Malaguna Road.
Roof is sagging and walls are leaning.



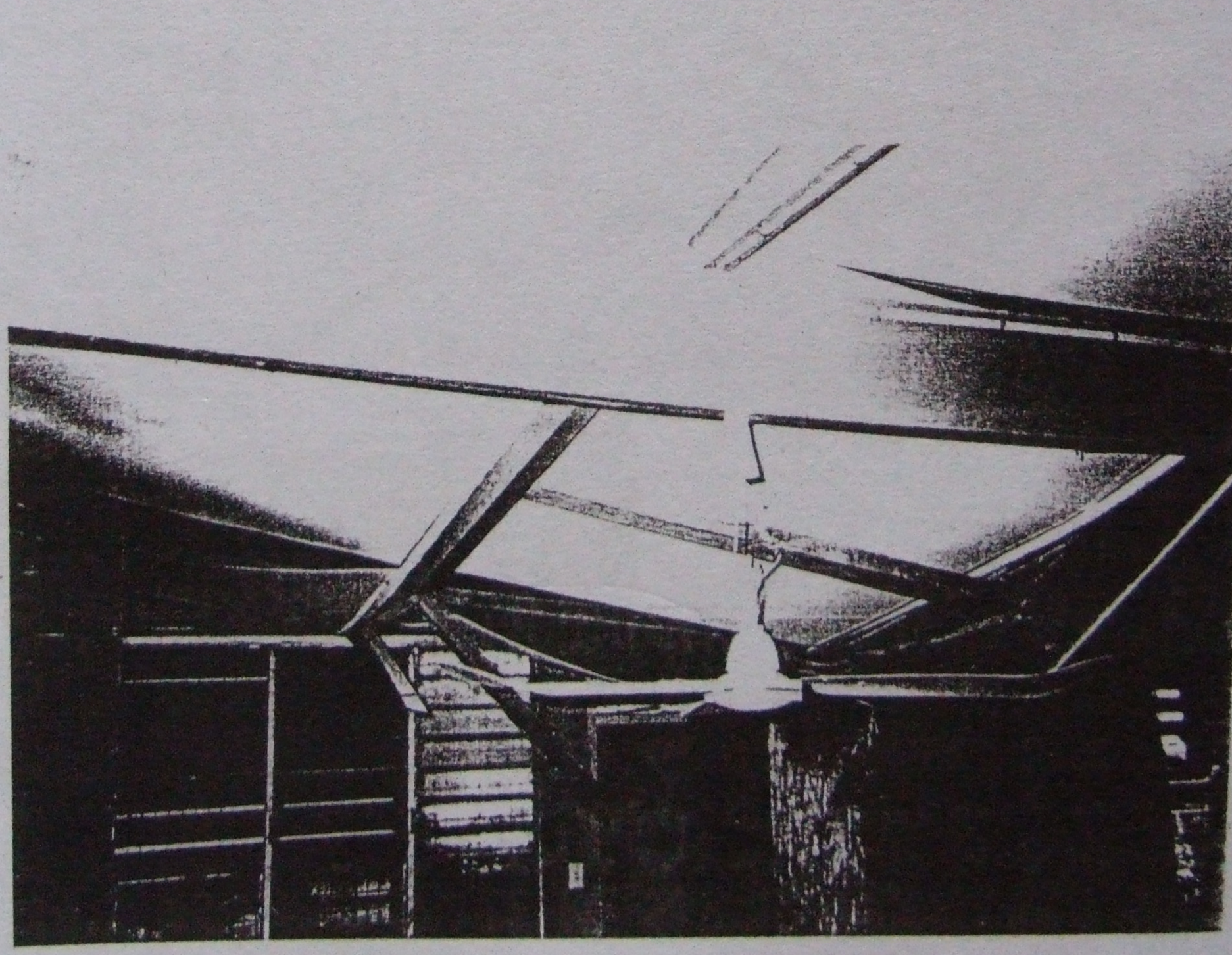
Inside Elcom's office in Malaguna Road. Roof has sagged under weight of ash



Elcom Housing



Elcom duplex in Aslan Street



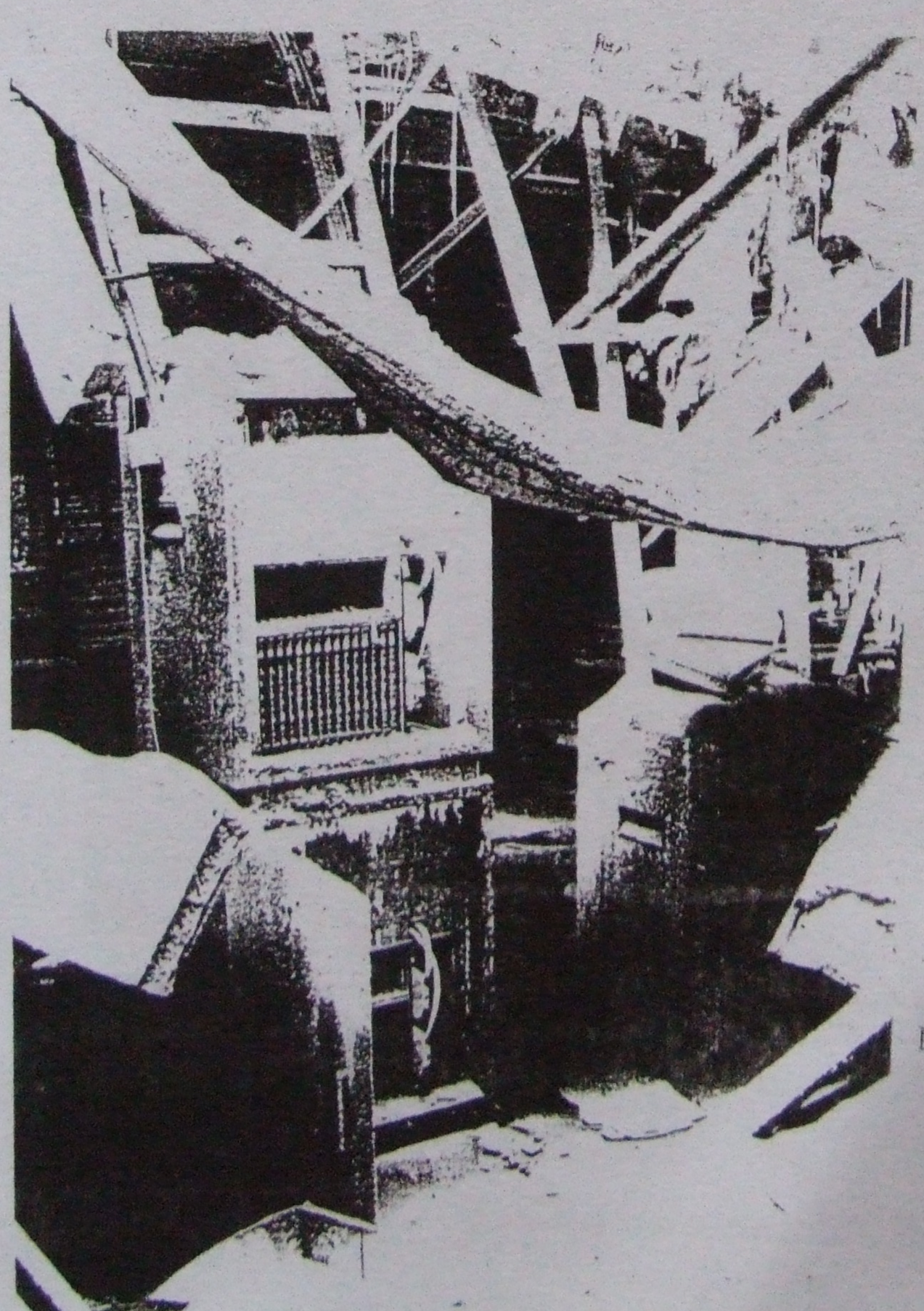
Inside duplex in photograph above



NBC transmitter site at Kurakakaul
AIDAB funded radio link to Bougainville
was abandoned on the day of the eruption.
It was only a few days from being completed.



Rabaul telephone exchange



Newly installed Telikom Customer Management system at the exchange



Telikom main stores building, adjacent to exchange



Telikom transmitter site and PTC houses in Tavur Street



Rabaul Post Office in Mango Avenue, opened in 1992
Post boxes in foreground



Rabaul Post Office